SPARKS FROM A GEOLOGIST'S HAMMER.

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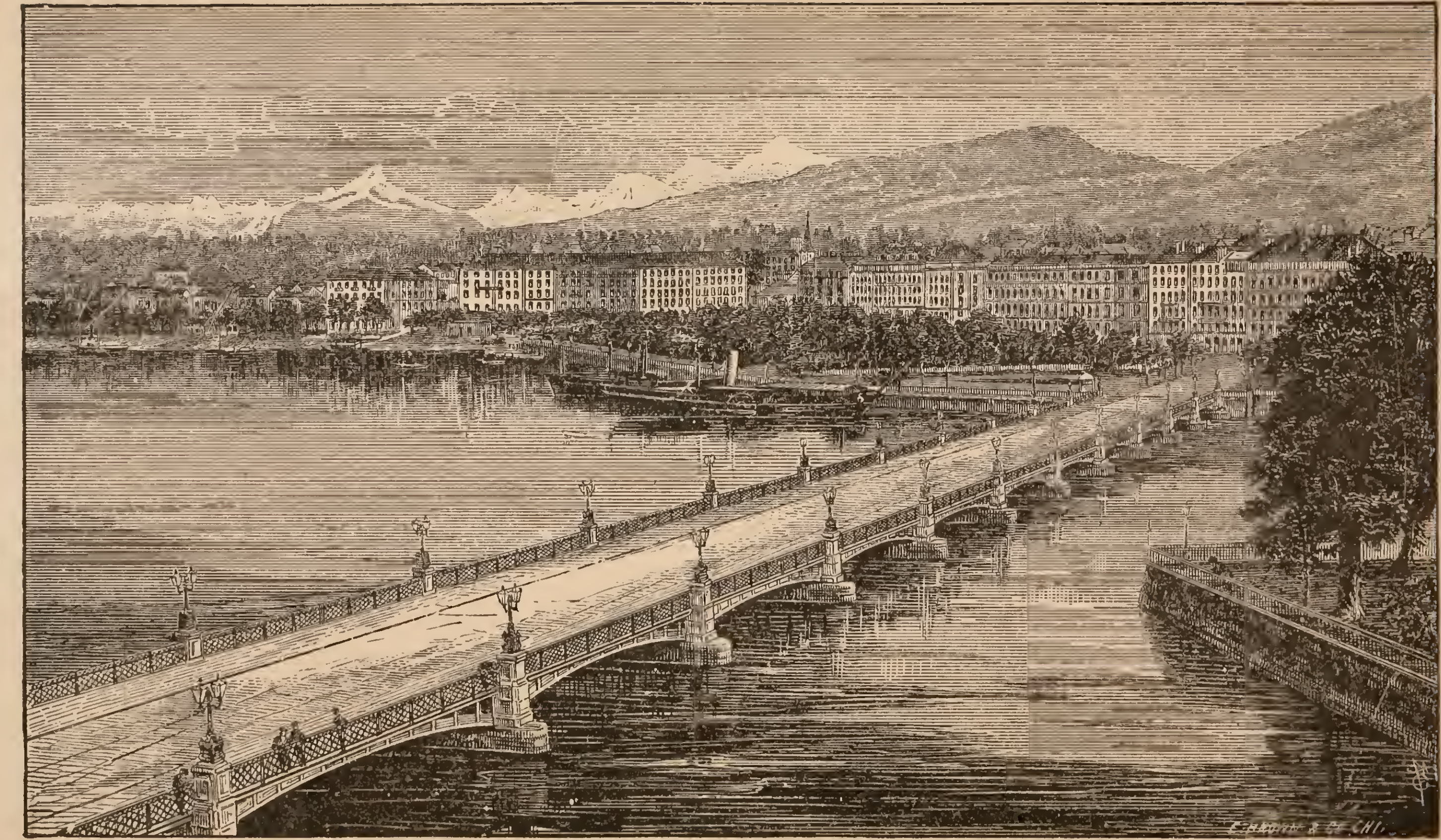

MONT BLANC AS SEEN FROM GENEVA.

SPARKS

FROM A GEOLOGIST'S HAMMER

BY

ALEXANDER WINCHELL, LL.D.

Author of "Preadamites," etc. etc., and Professor of Geology and Palæontology in the University of Michigan

Das wichtigste Resultat des sinnigen physischen Forschens ist dieses, den Geist der Natur zu ergreifen, welcher unter der Decke der Erscheinungen verhüllt liegt.—A. v. Humboldt

I think it wise sometimes to shut up shop and walk in the twilight, and look up at the stars or down upon the sea.—J. P. Lesley

SECOND EDITION

CHICAGO
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1882

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TO

LOTIE,

VOX, VITA, VIS.

1868—1874.

PREFACE.

The present work consists of descriptions, essays and discussions on such themes as may be conceived suited to occupy the attention of a geologist who tries to contemplate his vocation in the whole breadth of its relations. The themes range from descriptive and literary to scientific, historical and philosophic, while the style of their treatment is intended to suit the general reader. They present the results of some of the collateral and recreative occupations of science, rather than of its most serious and characteristic efforts, and should possess, therefore, a general interest. The scientist on his vacation becomes very much like other people. He feels, thinks, imagines, and enjoys, only with an intenser action in consequence of penetrating a little deeper into the nature, relations and significance of things around him. In the intervals of his serious work his attention is engaged by the subjects which interest other men; and if his intelligence is many-sided, he must feel that he has something to say on many topics. His scientific habits, acquired under the rigorous exactions of his profession, confer upon him a peculiar aptitude for observation, and a safe facility in reaching conclusions.

For many reasons, indeed, it is desirable that men engaged in science should turn their attention frequently to the subjects which interest their fellow scientists and fellow men. Such a course will save them personally from entertaining narrow views of the world. It will also tend to identify them with the society in which they move, and will conciliate toward them and the sciences which they pursue the respect and consideration of those who have it in their power to determine, to a large extent, the position and influence which scientific men shall enjoy. This end, which all scientific students must recognize as desirable, will be further promoted by the employment of a style inspired by that warmth and animation which the great truths of science are so well adapted to impart, and which even the inexpert are so capable of appreciating.

It is especially desirable that persons of the requisite aptitudes should seek to possess themselves of a wide range of scientific knowledge; since it is only by this means that the connections of the sciences can be discovered, and their relations to a system of universal truth adequately understood. Only by such means can the jealousies and bigotries which have sometimes defaced the pages of the history of science be avoided. Most of all, it seems desirable to infuse into scientific thought a more philosophic spirit; since all the great problems propounded by modern science are essentially philosophic in character, and rapidly lead the analytic mind into the domain of metempirical phenomena and conceptions. It is hoped, therefore, that the metaphysical turn which the author's thoughts have sometimes taken will be recognized as sustaining most legitimate relations to the system of science.

Some parts of the present work will be found conceived in a spirit of playful irony, at which, it is hoped, no reader will discover occasion for offense. Certain errors have seemed to call for animadversion, but no word has been recorded wherein has been inserted any intentional sting.

THE AUTHOR.

ANN ARBOR, September 6, 1881.

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SPARKS FROM A GEOLOGIST'S HAMMER.

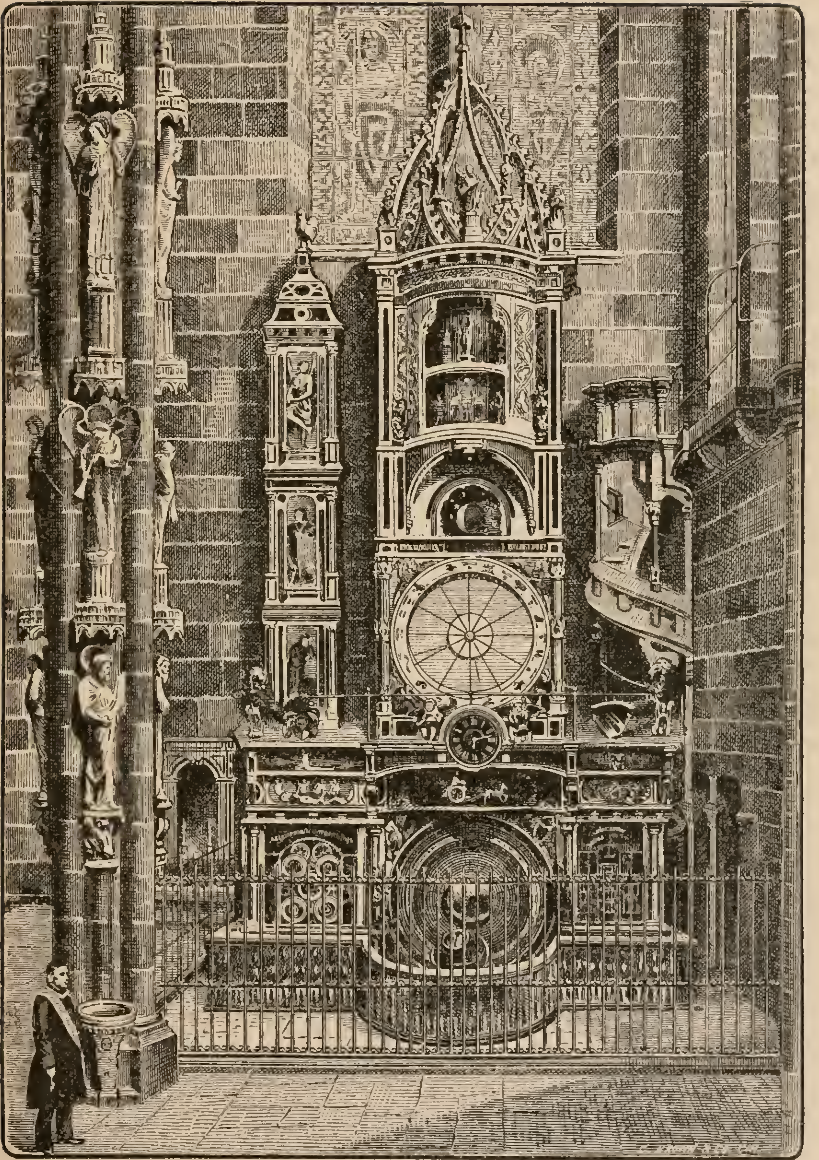
MONT BLANC AND THE MER DE GLACE.

THE Alps, towering a present reality before our eyes—the glaciers, opening their dark crevasses at our feet, and lifting their crystal pinnacles above our heads,—these are the scenes which the reader is invited to enjoy. I do not propose to treat him to a dry description of a range of mountains four thousand miles away. He will go with me at once to the land bristling with rocky "needles," and proud in its hoary mountain-tops, which glisten with the ancient rime of a thousand years,—the land of Mont Blanc and the Jungfrau, of the Wetterhorn and the Matterhorn and the Finsteraarhorn, and many another sonorous mountain "horn."

We set out in the morning from Brussels—another Paris on a smaller scale,—and passing within sight of the historic field of Waterloo—"the grave of France, the deadly Waterloo"—traverse the Grand Duchy of Luxembourg, wedged in among the greater nationalities like an imperiled skiff in an ice-floe, and then run down through those beautiful provinces of Alsace and Lorraine, which to-day are weeping with heads bowed low, like loving daughters torn from an affectionate mother. At Metz we view the vast and magnificent circumvallation of earthworks from which arose in recent times that roar of cannonry which jarred the ears of the world. Winding through the rugged region of the Vosges mountains, we arrive at Strasbourg, where we spend the night. Here we pay a visit of curiosity to the most famous clock in the world, and gather some fragments of the Cathedral tower, which rises over it,— brought down by the missiles from the German camp.

This celebrated astronomical clock was constructed by Schwilgué, and completed in 1842. The globe beneath shows the course of the stars; on the left is a piece of mechanism exhibiting christian chronology; on the right, the geocentric opposition and conjunction of the sun and moon; above it, a dial determining the intervening time; still higher is shown the course of the moon. As noon approaches, an angel on the first gallery strikes the quarters on a bell in his hand; higher up, a skeleton, representing time, strikes the hour of twelve. Figures around it strike the quarters, and represent man's progress through boyhood, youth, manhood, and old age. Under the first gallery, the symbolic deity of the day steps out into a niche,—Apollo on Sunday, Diana on Monday, and so on. In the highest niche, the Twelve Apostles move around a figure of the Savior, bowing as they pass. On the highest pinnacle of the side-tower is perched a cock, which flaps its wings, stretches its neck, and crows, awakening the echoes of the remotest nooks of the Cathedral.

Here in Strasbourg the art of printing was invented in 1440, by Johann Gutenberg, and the house in which he is said to have lived still remains standing. The art of using reversed letters carved on wooden tablets had been



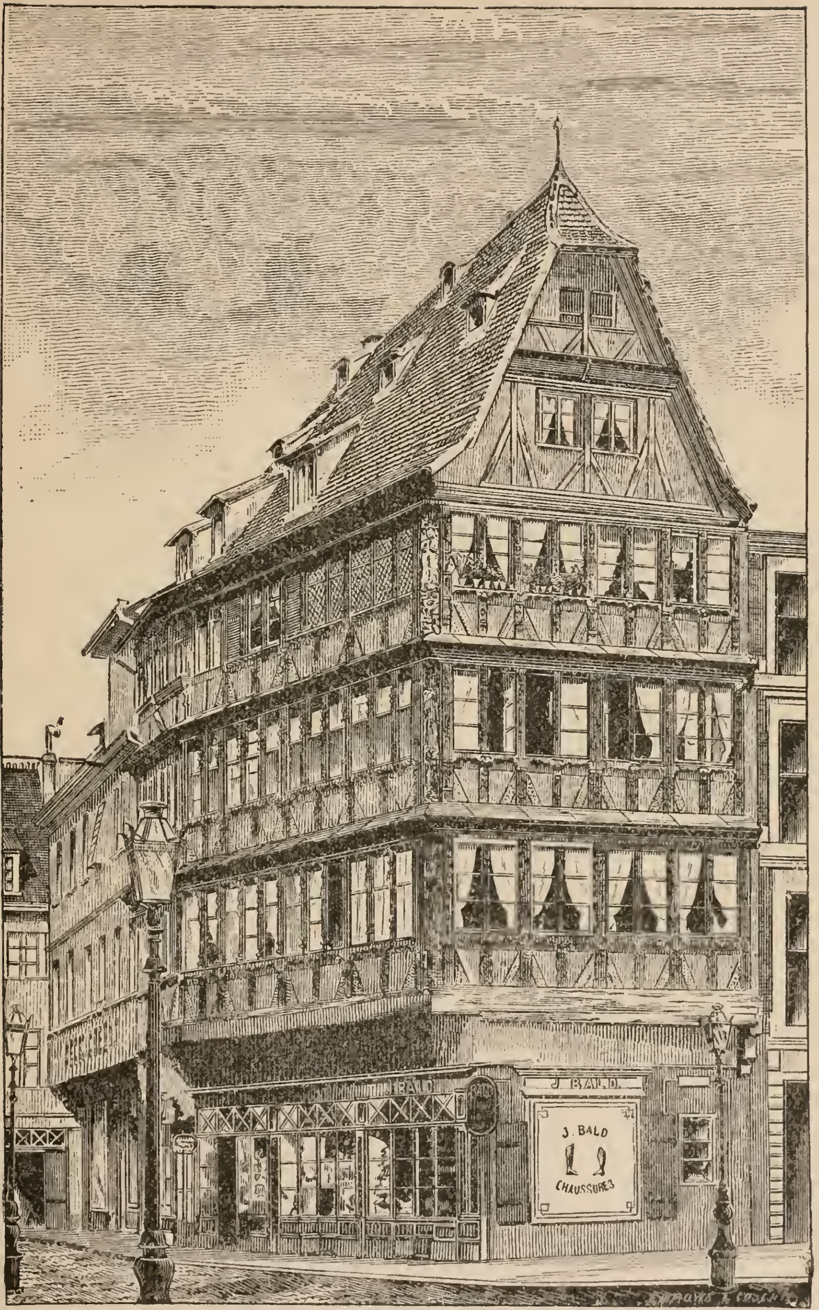
CLOCK IN THE CATHEDRAL AT STRASBOURG.

previously practiced, but Gutenberg first introduced movable types. The Bible was the first book printed. It appeared at Mayence in two folio volumes in 1456.

As we sweep around the city, on our departure, the form of the grimy old Cathedral rises so grandly and loftily above the Alsatian capital that it seems to hold possession of the plain in a sort of solitude,—that solitude which those experience whose loftiness of character finds no companionship in the common herd of men. The total altitude of the tower is 524 feet, this being the loftiest building in Europe. St. Martin's, at Landshut, in Germany, is 483 feet; St. Peter's, at Rome, 455 feet; St. Paul's, in London, 340 feet.

At Basel, the rushing Rhine is turbid and cold with the contributions of a hundred glacier torrents. As its restless waters hasten from our presence, thought follows them, spinning a thread of storied recollections from end to end of the classic Rheingau. At Basel is a most venerable cathedral, founded in 1010, the seat of the great Council of 1431, convened to effect a reformation in the church.

Leaving Basel we ascend the valley of the Aar, whose roaring torrent babbles of a recollection of the mountain and the glacier, and whose turbid waters and pebbled borders proclaim our advent in the region of the Jura Alps. The name of the river and of the two Aar glaciers in which it takes its rise is memorable. It recalls the name of the illustrious savant Agassiz, who in 1841 erected his hut upon the glacier, and studied, with a few chosen companions, the laws of glacier motion, laying the foundation of the bold theory, since accepted as a doctrine of science, that a general glaciation once visited the whole northern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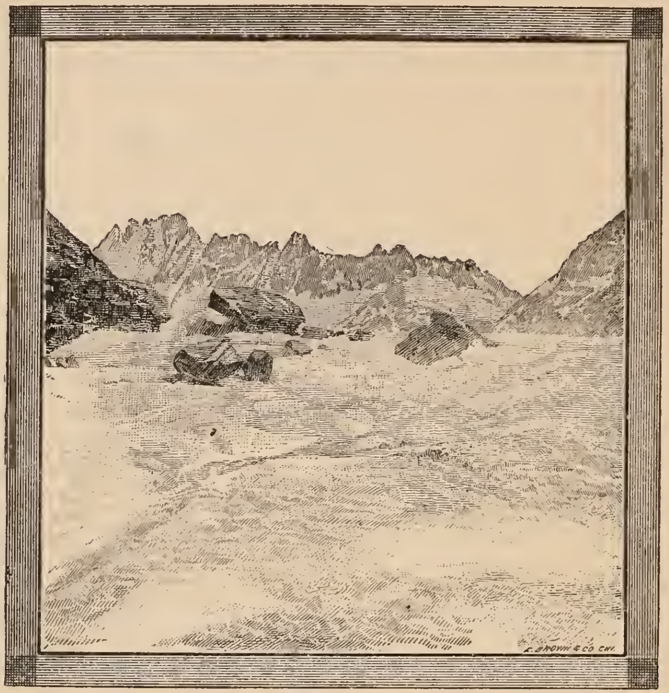
CHAUSSURES

THE HOUSE OF GUTENBERG, THE INVENTOR OF PRINTING.

hemisphere.* From this spot was fittingly brought a huge mass of Alpine granite, to commemorate the final resting-place of his mortal body in the beautiful cemetery of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ERRATIC BLOCKS ON THE GLACIER OF THE AAR. THE SPOT WHERE AGASSIZ AND HIS COMPANIONS ENCAMPED FOR THE INVESTIGATION OF THE GLACIERS. FROM A PHOTOGRAPH ON GLASS BY J. LÉVY ET CIE., PARIS.

* The eminent Swiss naturalist, Hugi, in 1827 caused a hut, now in ruins, to be constructed on the ice at the junction of the two glaciers — the Ober and the Unter-Aar glaciers. This, in 1840, had been transported by the glacier to the distance of 5,900 feet. It was on the same glacier that Agassiz, then professor at Neuchâtel, erected, at the expense of the King of Prussia, the hut from which his celebrated observations were made. He was accompanied by Messrs. E. Desor, C. Vogt, Wild and others. The accounts of their observations, published in the Augsburg *Allgemeine Zeitung*, were dated from "Hôtel des Neuchâtelois." On the summit of a rocky projection, near the same spot, a "pavilion" has been more recently erected by M. Dolfuss-Ausset, of Mühlhausen (in Alsace), and here he passes some weeks of every summer.

Mount Auburn, a rude but eloquent monument, in its externals as unlike the imposing sculptures which surround it as in the interest it awakens more touching, more inspiring and more catholic. On one side is engraved:

JEAN LOUIS RUDOLPHE AGASSIZ.

On the other:

BORN AT MOTIER, SWITZERLAND, MAY 28, 1807.
DIED AT CAMBRIDGE, MASS., DECEMBER 14, 1873.

And on the edge:

*Boulder from the Aar Glacier.**

Winding through the gorges, often vineyard-fringed on either hand, we come out at length into the broad valley of Switzerland, resting between the Jura and the Bernese Alps. The Alpward glimpses and nearer landscapes begin to infuse in us an unwonted inspiration. The lake of Biel and the lake of Neuchâtel stretch their skiff-dotted surfaces before us in summer serenity,—as if to rest the eye which must climb the weary steeps of the stupendous mountains rising in the far horizon. Now and then a glistening spectacle is briefly revealed through the rifts in the clouds, and we strain our eyes and wrench our necks to make the most of this first revelation of eternal snows. Now, by irresistible association, we recall those lines in the "Childe Harold" where, posted in this very valley, the wanderer thrills at the spectacle presented by the sublimities of Nature.

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* In according to Agassiz the great credit of placing the "Glacier Theory" on a firm foundation, we must not overlook the work of his predecessors. In 1815 Playfair attributed to glaciers the transportation of erratic blocks. In 1821 M. Venetz advanced the opinion that the glaciers of Valais and adjacent regions had formerly a vastly greater development than at present (Venetz, *Mémoire sur la temperature dans les Alpes*, 1821, in Mémoires de la société helvétique des sciences naturelles, vol. i, pt. 2). M. Venetz does not in this memoir attempt to explain by the same means the *general* phenomena of the boulder formation, but it is reported that some years later he gave this extension to his views. In 1829 Goethe clearly shadowed forth the same theory in *Wilhelm Meister's Wanderjahre*, vol. ii, ch. 10. In 1834 M. Jean de Charpentier, in a memoir read before the "Helvetic Society of Natural Sciences," at Lucerne, on the probable cause of the transport of erratic blocks in the valley of the Rhone (See *Annales des Mines*, viii; also in German, in Froebel and Heer's *Mittheilungen aus dem Gebiete der theoretischen Erdkunde*, p 482 *seq.*), presented substantially the modern theory of glacier transportation. This paper was the occasion which directed the attention of Agassiz to the same investigation, and hence, in 1836, he spent some months in Charpentier's vicinity for the purpose of making observations for himself (Charpentier, *Essai*, p. 1).

In 1837 M. Agassiz, as president of the same society, delivered at Neuchâtel an opening discourse on this subject. It gave rise to a discussion which occupied a large part of the time of the session.

In 1840 appeared Agassiz' great work, *Études sur les Glaciers*, with an atlas of thirty-two plates. In the same year appeared works by others — Godeffroy, *Notice sur les Glaciers, les moraines et les Blocs erratiques des Alpes*, Paris and Geneva; Le Chanoine Rendu. *Theorie des Glaciers de la Savoie*, Chambéry. M. Jean de Charpentier's *Essai sur les Glaciers* was then written, but it seems not to have been published till 1841.

> * * "Every mountain now hath found a tongue,
> And Jura answers through her misty shroud
> Back to the joyous Alps, who call to her aloud."

Vines, vines, on every hand. At Neuchâtel we have reached the early home of Agassiz. We look down on the little city from the high grade of the railroad, upon the brown tiles of the housetops and the classic lake beyond, and warm with sentiments of interest and affection for the sake of a single name. We have chosen the route through Neuchâtel for the sake of this inspiring moment. Down by the lake rises the new college edifice, in which is preserved the old collection of specimens gathered by Agassiz while professor here.

But now all this is left behind. Vines, vines, on every hand lean upon little stakes, which bristle all over the steep hill-sides. The name of Concise from the train-conductor's lips turns our attention to a quaint old town, whose enterprising scientists have dredged from the lake-bottom a large collection of curious relics of the habitations of our prehistoric ancestors, erected upon piles in the lake.

Grandson, which the conductor announces as "Grasso," wears a still more ancient look, and suggests that it is in reality the grand*father* of all these Swiss towns, having been built during the Roman occupation. At Yverdon, at the foot of the lake, we pass the former home of Pestalozzi, the great reformer of primary education and the inaugurator of that system of "object teaching" now grown into general acceptance.

Coursing rapidly over a region of peats, dug by squalid rustics, and spread out like the grass of New England meadows, to dry in the sun, we plunge down upon one of the prettiest little cities that eye ever rested upon—Lausanne, perched upon the steep slope which overhangs the lake of Geneva. Toward the left, the blue water carries the eye as far as Vevay and the historic Castle of Chillon; toward the right, the shimmering surface stretches to the city of Geneva, our immediate goal, a name redolent of varied reminiscences of mediæval and modern times; while in front of us, beyond the placid breadth of the lake, roll up in receding grandeur the dark mountain summits of Chablais. Behind them, we know that the snow-mantled pinnacles of the Mont Blanc range rise in cold serenity, but the jealous clouds enwrap them from human eyes, as if fearful that the home of frost and cloud and ether would be desecrated by the too familiar gaze of mortals. So expectation recedes from weary tip toe, and we glide down into the city of Calvin and Servetus, and "the self-torturing sophist wild" Rousseau, and the "Joint High Commission," and the ticking of a million watches, and the polyglot sounds which emanate from a thousand hotels and boarding-houses.

Geneva, for beauty of situation, stands first in the list of cities; and of all the lakes in the world, there is not one so enchantingly framed in mountain magnificence, so sweetly toned down to the grassy beach on which it ripples, as the historic and richly storied lake of Geneva. The amphitheater which surrounds the lake is dotted with many a classic and luxurious villa. The villa Diodati, on the southern shore, was once the residence of Lord Byron. On the north shore is Ferney, a village created by Voltaire; and his unostentatious château may still be visited there. At Pregny is the magnificent new villa of Adolf Rothschild, from which the welcome visitor enjoys a view of Geneva — lake and city — and of the amphitheater of mountains, backed in the far southeast by the snowy range of Mont Blanc, displaying a charm of landscape which causes one to wonder if any resources of beauty or magnificence are reserved for the enchantments of the heavenly land.

At the eastern extremity of the lake, on an isolated rock connected by a bridge with the shore, stands the Castle of Chillon, now only a military arsenal, but for nearly a thousand years a stronghold in whose gloomy dungeons have been incarcerated the victims of petty tyranny and religious bigotry. Here, in 830, Louis le Débonnaire imprisoned the Abbé of Corcier. Here many of the early reformers were chained to the dungeon walls, and in more recent times prisoners of state have trod the stony floors; and here are shown, to this day, the footprints of Bonnivard, consigned to six years of imprisonment by the tyrannical duke of Savoy in 1530.

"Chillon! thy prison is a holy place,
And thy sad floor an altar,—for 'twas trod
Until his very steps have left a trace,
Worn, as if the cold pavement were a sod,
By Bonnivard!—may none those marks efface!
For they appeal from tyranny to God."

Prisoner of Chillon.

The old city of Geneva is separated from the new by the Rhone, whose deep blue waters shoot beneath the six connecting bridges with the swiftness of an arrow. The Rhone enters the lake at the opposite extremity turbid with the sediments brought down by the torrents born of a hundred dissolving glaciers. These sediments, settling in the lake, have filled it up for a distance of thirteen miles, to Bex, from its ancient limits. The geologist can scarcely resist the reflection that this work is not of such magnitude as to defy the powers of imagination to grasp the time required for its performance; and yet this is all that the river has accomplished since the last geological revolution. To the prophetic eye of science it appears equally certain that the work of filling the lake completely must be accomplished in some finite period.

The Rhone itself issues as a gray torrent of snow-water from an ice-cavern at the foot of the great Rhone-glacier, above which rises the Galenstock to the height of nearly twelve thousand feet. In the language of the ancients, this river was said to issue "from the gates of eternal night, at the foot of the pillar of the sun." From this spot it pursues a journey of five hundred miles to the Mediterranean.

Never to be forgotten is the first full view of a range of mountains capped with eternal snows. It would be a calamity not to gain this first view from the city of Geneva. We may have been in the place three days, or a week; but though we know the Mont Blanc range should be visible, the jealous clouds have interposed an impenetrable veil. To-day, however, a purifying influence has gone through the air, and the vapors have seemed to dissolve before it. The sun has now just disappeared behind the Jura range. We saunter from the dinner-table down to the Quai, which faces eastward toward Mont Blanc. There the long-sought vision of glory is revealed.* This is indeed the first view of mountains mantled in perpetual snow. Nothing like it have we ever seen. There is no other terrestrial glory with which to compare it. Exclamations there are none. The instincts of the mind and soul consign all adjectives to contempt. We can only gaze, and wonder, and enjoy. We are transfixed. Our most expressive language is silent admiration.

Must we mock this transcendent scene with a description? Yonder in the distant horizon stretches the serrated crest of the Mont Blanc range. It is all luminous with the light of the setting sun. Its brilliancy is more dazzling than crystal. It looms up behind the darkened intervening hills like the very parapet of heaven above the earthly horizon. It is so unlike everything else seen upon the earth that it seems to be not of the earth — a very vision of supernal glory.

Among these Alpine summits it is not possible to mistake the sovereign mountain. At the right, Mont Blanc lifts his regal front highest, and stands at the head of the column. Next to the left are the Aiguilles du Midi, and next come the Grandes Jorasses and the Dent du Géant. Some distance below these crystal summits still blazing in sunlight, float fleeces of cloudy drapery, like vestments dropped from the balconies of heaven. In front of this range, and at a lower level, shoot up the pinnacles of the Aiguilles Rouges; and still more in the foreground, wrapped in sunset shadow, rise the Môle, like a pyramid from the plain, the snowy summits of the Aiguilles d'Argentière and the broad Buet.

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* See Frontispiece.

Now pausing to breathe, we notice the long ridge of the Voirons closing in upon the extreme left, as the Great and Little Salève uplift their rock-ribbed forms upon the right. Still nearer is the dark mass of foliage which shelters the city suburbs and fringes the further border of the lake; and here, immediately before us, stretches lake Leman, clear and placid, whose very name is redolent of poetry, and whose darkening surface is now animated with the movements of a hundred pleasure-skiffs which

> "Drop the light drip of the suspended oar,"

while their merry occupants drink in the music of each other's souls.

But while we gaze the twilight shadows thicken. See! Not only are the Môle and the Buet sunken in shadow, but the broad line of night has crept up the snowy flanks of the higher mountains. Their summits are still smiling sunset adieus; but the shadow of Jura glides steadily up the Alps. Lo! now the glory of Mont Blanc is dimmed. An ashy paleness steals insensibly over the gem-lit brow of the mountain monarch. His form fades by degrees into the dull hue of the background sky. The snowy range is no longer discernible—vanished from mortal eyes into the very heaven to which its supernal glories seemed to belong. It is sunset—it is twilight—it is evening; and we turn with a feeling of revulsion and discontent from the splendors of Nature to the jargon of the babbling throng in the street.

The highway from Geneva to Chamonix is a finely macadamized turnpike. Communication is maintained during the summer by means of lines of daily stages known as "diligences." Between the proprietors of these a sharp competition exists for the patronage of the traveling public, whose plethoric but ever-bleeding purses sustain not only the lines of diligences, but also half the other business of the city. English-speaking travelers are a chief reliance of Genevese tradespeople and proprietors of means of conveyance. But of all nationalities, the American is regarded as the fattest and most lawful game; and the vultures of trade gather around him with an attentiveness which may be very flattering, though certainly very expensive. The idea obtains that the purse of the American is always aching with distension, and that he is perfectly willing to receive politely offered relief. It is naïvely admitted by Genevese tradespeople that they have four prices in ascending order:—the first for citizens; the second for Germans and Italians; the third for the English, and the fourth for Americans, whom they declare it right to tax one hundred per cent above the citizen.

Accordingly, the agents of the several lines of diligences posted before the doors of their offices, along the Grand Quai, ply every stranger who ventures through their precincts. The fare to Chamonix and back, if you are quartered in a hotel, is thirty-six francs, of which six go to your landlord. There is little difference in the accommodations of the different lines. In front, underneath the banquette where the driver sits, with room for two others, is a closed coupé with a seat for three. The body of the vehicle is occupied by three other seats, each with room for three. Underneath the rear is a capacious repository for baggage.

At seven o' clock in the morning we repair to our diligence and take possession of the seats previously engaged. Six horses whirl us out of town at the top of their speed. The route lies up the valley of the Arve. The scenery at first is lacking in features of striking interest. At Bonneville, 15 miles, we pass, to the left, the pyramidal mountain of the Môle, over 6,000 feet high (6,128 feet). At Balme two cannon are planted by the road-side, which for a fee of one franc will undertake to wake the echoes in the high cliffs opposite.

The mountains now rise in loftier grandeur upon the right and left, and flocculent clouds hang on the red crags or drip down their precipitous slopes. One cannot help remarking how these wisps of vapor love to cling to the solid earth. The open atmosphere above the valleys may be free from clouds, but they seldom cease to hover about the high-lifted forms of the mountains. I am inclined to think they are drawn to these masses by what we call gravitation,— as light particles, floating on the surface of a vessel of water, are drawn from all directions toward a larger floating body.

Approaching Magland, a striking phenomenon bursts upon us. A stream of water gushes from the vertical rock wall on the left, and plunges down 500 feet, as if an immense tank had been tapped and the plug drawn out. Above rise the Aiguilles des Varens, nearly 9,000 feet (8,960) high. These, undoubtedly, gather the precipitation which supplies the flow,—a small lake (lac de Flaine) upon the heights, probably serving, as De Saussure suggested, as a reservoir to maintain the constancy of the supply.

Glancing ahead, we soon descry, at the distance of a quarter of a mile, another cascade,—the cascade of Arpenaz. This pours from the brink of the precipice, plunging sheer into the atmosphere at the height of 860 feet, and separating into vapor before reaching the solid ground.

Alpine characteristics grow more emphasized. The muddy Arve rushes past us with a noisier utterance,—rippling, eddying, plunging about the rocky fragments which have invaded its bed. The bottoms are strewed with the traces of a recent flood,—stones, gravel, and mud gathered in winrows and deposited at elevations several feet above the present level of the stream. The whole valley is in a state of devastation. Man has here yielded dominion to the caprices of torrent and flood.

At St. Martin the highway makes a sharp curve to the left, and the valley gorge opens a vista in a new direction. Suddenly Mont Blanc stands up before us,—white, lofty, majestic, and overpowering. It is like another apparition from the celestial regions. We at once recognize a difference between our emotions and those experienced at Geneva. There, the scene was grand and exhilarating; but beauty and softness and distance were so blended with it that the soul preserved a comparative calm. Here, the monster mountain rises apparently in our immediate presence,—lofty, brilliant, vast, majestic, and mighty. The sentiment of sublimity is mingled with a feeling of nascent fear. Even the heart begins to leap, sympathetic with the external incitements. The impression is so different from the former one that the scene appears new. But there is the same supernal glory in it. The white, immaculate, luminous mass is so unlike anything earthly which we have seen that it appears as an appurtenance of the blue sky against which it rests. I think, if I had not first seen Mont Blanc under the mellowing guise of distance, and the vision had first burst upon me at this spot, I should have bowed to the ground before it. The power of that presence can only be felt. I wonder not that uncultured nations pay adoration to mountains. I wonder that any cultured man can come into the presence of Mont Blanc without being crushed to the earth by the weight of the sentiment of worship.

Still, the appearance of proximity is deceptive. Mont Blanc, though seemingly within half a mile, is removed not less than 12 miles in a direct line; and Mont Forclaz, itself nearly 5,000 feet high (4,911 feet), rises almost unnoticed in the intervening distance. This is a characteristic deception experienced from the colossal dimensions of the features of Alpine scenery. First views seldom respond to our preconceptions in respect to measurements. What seems a half hour's walk will prove to be a wearisome five hours' climb. The cascade which, at home, you would give, by estimate, a height of fifty or a hundred feet, you will find, by measurement, to fall five hundred or a thousand feet.

At the Baths of St. Gervais we pause for a repast.

Sulphur springs and a fine cascade (cascade de Crepin) are near. The mountains now crowd down upon the highway. The deep, narrow gorge through which the Arve comes, with shouts and summersaults, down from the valley of Chamonix, serves only for the torrent's accommodation; and the French government has chiseled a giddy roadway along the face of the perpendicular cliff of the Little Tête Noir (5,800 feet),—giddy, but secure, and worthy of France. The nose of the mountain, however, is at length pierced by a tunnel, the exit of which happens to be within a few feet of an old Roman tunnel, recently exposed to view. The latter is about eight feet high and as many in width.

Soon we have reached a miserable village, called Les Ouches (3,143 feet). The village of Chamonix lies before us. At our right is uplifted the tremendous form of Mont Blanc, dazzling in the afternoon sunlight. It seems incredible that these immaculate and shining solitudes are still so remote. But there hang the clouds, half way down the mountain sides. Now, for the first time, a real glacier greets our eyes. The long coveted gratification is at length granted. This is the glacier of Taconnay, half hid in its deep excavated valley, but revealing itself as a white snake like form crawling down from the home of perpetual snows. A further advance, however, reveals the existence of an intervening valley, which holds the shrunken form of another ancient accumulation of ice. This is the Glacier de la Gria. A few minutes further and the long, swelling form of the Glacier des Bossons comes into sight.

Are these, then, the glaciers? We thought them broad fields of almost impassable ice, and here they lie revealed merely as snowdrifts in Alpine valleys but a few rods in width. No deception could be more complete. It is our apprehension that disappoints us; it is enlarged. Let us reserve our opinions till we have laid our hand upon the cold nose of the glacier, and made the attempt to scramble over its back.

As we pass the village and Glacier des Bossons, our satisfaction increases. The lower extremity of the glacier lies across the river bottom at the distance of about a mile. It seems to have come down to the homes of men to demand apology for intrusion upon its ancient domain. And yet this terminal point is at half the altitude of Mount Washington above the sea. We can here discern distinctly the tremendous pile of detrital material which the glacier has brought down and piled about its lower termination. We see these rocky ruins stretched all the way across the mile which separates the village from the glacier; and thus make our first note on the evidences of glacier diminution.

The next glacier to come in view is des Bois, which likewise creeps quite down among the habitations of men. But the village of Chamonix lies between us, and we at length dismount from the diligence, after a magnificent ride of fifty miles in seven hours and a half. Chamonix (3,445 feet, 2,500 inhabitants) is a bright and cheerful village on the surface, but with a great deal of antiquity just beneath the whitewash and paint. Fifteen thousand visitors annually ask for shelter beneath the spreading roofs of its numerous but modern and entirely comfortable hotels. The needs of these visitors supply almost the sole occupation for the inhabitants. Of the eight first-class hotels, seven belong to a single company. The charges are uniform, and when we aggregate all the particulars, are rather high. The business of the guides is also reduced to system, uniformity and certainty. Charges for various trips, with and without mules, are specifically regulated by law, and the Chief of the Guides is charged with its execution. There is, even here, however, one uncertain element in all calculations, and that is the "pour boire," or gratuity which the employé always expects in addition to the legal allowance. The lavish practices of American travelers have swollen this tax from a few centimes to one, two or five francs, and has educated the guides to a degree of trained ingenuity in devising pretexts for extra charges. About three-fourths of the visitors to Chamonix come from Great Britain and America, the remainder are mostly French with an admixture of Italians, Russians and Spaniards. The English language is quite universally spoken in the hotels, though the French is the language of domestic intercourse, and, strangely enough, the exclusive dialect of the guides. I did not meet a person in Chamonix who was able to transact business in the German language.

The snowy summits of the high Alps now hedge us in on every side. On the southeast is the Mont Blanc range, rising from our very door-steps, with Aiguille du Gôuter and Dome du Gôuter resting on the shoulder of Mont Blanc. Dome du Gôuter, from our position, simulates the character of the monarch himself, for it stands between us. On the northwest side stand the Flegère (5,957 feet) and the Brévent (8,284 feet), bold buttresses of the Aiguilles Rouges, which rear their red pinnacles in the distance behind these mountains.

* * "Above us are the Alps,
The palaces of Nature, whose vast walls
Have pinnacled in clouds their snowy scalps
And throned eternity in icy halls
Of cold sublimity, where forms and falls
The avalanche — the thunderbolt of snow!
All that expands the spirit, yet appals,
Gather around these summits, as to show
How earth may pierce to heaven, yet leave vain man below."
Childe Harold, III, lxii.

Following the prevailing custom, our first excursion shall be to the Montanvert (6,302 feet). This is a buttress of the Aiguille de Charmoz (11,293 feet), and is visited exclusively to obtain a view of the Mer de Glace. For this ascent a guide is unnecessary, and should we need one for the continuance of the trip, we may take the risk of engaging him upon the mountain. Our vigor is so exuberant in the youth of our experience, that we shall scorn equally mules and guides.

The well constructed bridle-path leads in a perpetual zigzag up the mountain. Passing first, the débris of a series of avalanches, which have mown long avenues through a forest of firs, we pause for refreshment at the Fontaine de Caillet. Here we obtain ice-cold water — which the guides around declare to be unsafe for a beverage,— having less regard, we suspect, for our health than for the sale of the bottled beverages within the cabin. At any rate, we conclude again to take the risks. Here is a rude chalet from which the traveler may reinforce his energies on red raspberries, vin ordinaire or cognac, according to his disposition. Here, also, is kept a living chamois, which is shown to visitors for a trifling consideration.

Refreshed, we resume our march. The sun has crept around on our side of the mountain, and the extract of muscle begins to ooze copiously through the pores of the skin. Spruce Americans ride past us on their donkeys, intelligibly conscious of the awkwardness of their attitudes and movements. The characteristic English woman, — thick, gelatinous and dowdy, — planted on a saddle two feet broad, capers along in the procession, while her John, whiskered after the stereotyped mutton-leg fashion, clad in his Scotch jeans, with a wild flower in his buttonhole, and lorgnette swung from his shoulder, perspires along the mule-path in her rear. But every situation has its compensations. Even now approaches a lad whose mien, and whose very position in the company which he leads, proclaim that he has crossed the Atlantic from a country which has celebrated the centennial of its independence. He is full of centennial. Fellow countryman, a salutation! Just behind is "pa," upon his mule, full of pride over his young American; and alongside is a pretty, jaunty young lady, whose profusion of smiles and conspicuous defiance of lookers-on proclaim her ready for anything prohibited to European girls. There is no mistaking it; this is the daughter. This is the "American young woman abroad." There is nothing so fresh, so charming, so inspiring, so satisfying, in all the breadth of the continent, as the American young woman. The man that could see this sylph float past him, or listen to the music of her prattle, — so full of nonsense, and yet so full of meaning, — without feeling moved to throw his hat in the air and hurrah for the American girl, is only fit to lead a mule by the bridle. Young man — old man — you will never appreciate your blessings until you find yourself in Switzerland, surrounded by those Swiss peasant women, — thick-set and nut-brown as the cows with which they consort, with form like a bag of meal, and gait like that of a Muscovy duck.

Outstripped so easily by our travelers on mule-back, we almost regret our resolve to walk; but should we pause a few minutes in the shade of the firs which border our path, many a pedestrian would also come up to report as a companion.

At length the stone-built house of refreshment, at the end of the path, shines through the trees. We stand upon the brink of a deep, rocky valley, and look down upon the surface of the world-famed Mer de Glace. We survey it for a moment, and our throats choke with disappointment and chagrin. How painfully beneath our anticipations! A pocket affair, indeed! And it seems incredible that anyone could need a guide to cross this piece of ice. We, at least, will assert our independence.

But the general perspective is grandiose and satisfactory. The steeple-like pinnacles of the mountains on either hand are overpowering in magnificence. On the right, as we look up the Mer de Glace, is the Aiguille de Charmoz (11,293 feet), eleven thousand three hundred feet high; on the left, the Aiguille du Dru (11,527 feet), eleven thousand five hundred feet high; and directly before us, but more remote, the enormous masses of the Grandes Jorasses (13,786 feet), thirteen thousand eight hundred feet in height. From this direction we gather a more adequate idea of the magnitude of the glacier-field before us. Two miles up the stream of ice — it seems, indeed, but half a mile — the glacier widens and bifurcates. The tributary from the right, visible only at its termination, is the Giant

Glacier, which stretches five and a half miles to the summit of Mont Maudit, gathering into itself all the snows over a vast expanse. The tributary from the left bifurcates again into Glacier de Léchaud, whose axis is nearly a prolongation of that of the Mer de Glace, and Glacier de Talèfre, in the midst of which rises a soil-covered mass of rock (9,143 feet) nine thousand one hundred and fifty feet above the sea, walled in on all sides by mountains, and adorned in August with a display of several species of Alpine flowers. It is hence named the Jardin, or Garden.

From our position we now take a more contemplative survey of the features of the Mer de Glace. "Its surface," says de Saussure, "resembles that of a sea which has become suddenly frozen,— not during a tempest, but at the instant when the wind has subsided, and the waves, although very high, have become blunted and rounded. These great waves are nearly parallel to the length of the glacier, and intersected by transverse crevasses, the interior of which appears blue, while the ice is white on its external surface." Montanvert has always been a favorite point of observation and study of this glacier. The illustrious Goethe visited the spot in 1779; and he mentions in his Journal the fact that an Englishman named Blaire erected here a hut, from the window of which he and his guests could survey the sea of ice. This hut still exists, and affords accommodation for the guides. A projecting rock is still shown where two other Englishmen, Windham and Pococke, as early as 1740, found shelter during the night.

We are now rested from our weariness, and, following the established fashion, we should proceed to cross the

Mer de Glace. But our ambition is not satisfied to accomplish what everybody else is capable of achieving. Above us shoots the needling pinnacle of Charmoz, the flutings of whose precipitous slopes are laden with drifted snow. We dare not think of scaling this mountain spire, but here is a moderate acclivity clothed with grass and low bushes, which tempts us in that direction. Who volunteers for a scramble up a more considerable height?

There is no pathway here,—save occasionally a goat-path zigzagging aimlessly,—and our goal, if we have one, leads over a field which it would be temerity, if not an impossibility, for anyone to traverse encumbered with those entanglements known as female apparel. The ladies, perforce, must remain behind. They may amuse themselves with collecting Alpine flowers and putting them in press.

To relieve the ladies from wearisome waiting, and from the anxiety of a prolonged absence, we scramble hastily up the slope, to accomplish as soon as possible all that we shall dare undertake. Alas, how soon breath fails when man attempts to kick against the force of gravitation! Almost at the outset we find ourselves excessively disabled. We stretch ourselves out on the ground like dead men, and pant with all our might. Lying with our faces turned toward heaven, a raven black as night sails over us and calls out Kaw! and sails on in disdain. A few minutes suffice to revive us. Then we rise, and foolishly repeat our scramble and our exhaustion. But we make rapid headway.

For some distance we find the surface covered with dwarf huckleberries (*Vaccinium*), Alpine roses (*Rhododendron*), and heaths (*Erica*), with a scattered intermixture of grasses and a few other plants. Trees we left at Montanvert. These shrubs continue to diminish in size as we ascend, until the huckleberries form a low, thick, fur-like mat. These still grow shorter and shorter, and then abruptly disappear. We are on the limit of flowering vegetation. A desolate region of naked rocks surrounds us. These are not boulders or transported blocks, but the solid framework of the mountain shattered as if smitten by a colliding world, and hurled all over the surface. Smaller at the lower level, they grow more massive as we ascend. Some attain the dimensions of a dwelling-house,—huge, angular blocks chipped out of the mountain mass. They are all strongly laminated, and belong to the class known as mica-schist. At length we near some frowning cliffs, and observe that the stratification of these rocks is nearly vertical. Their thin, sharp layers sometimes present their edges at the surface like an array of knives. Over these angular rocks we clamber with great difficulty and danger of bruised shin-bones. The sloping crest of the mountain is not far at our right. This we succeed in scaling, and now the panorama of the valley of Chamonix is spread out before us. A fresh breeze meets us on this crest. The clouds are kissing and embracing the unresponsive rocks on every hand. They are beneath us and above us. They hasten past us as if unconcerned at our presence. Nay, they have embraced us. Avaunt! cold fog. Thou art not the rosy cloud which from the valley we have seen sleeping on the bosom of the mountain.

> "'Tis distance lends enchantment to the view."

But here, with all the exhilaration of the situation, we make one disheartening observation. This rude monument of stones proclaims the fact that others have preceded us. From what direction, or within what period, no record reveals. This, then, is not the satisfaction of our ambition. Onward to Charmoz! Charmoz stands now at our left. On our front the form of the mountain slopes rapidly down toward the valley of Chamonix. Behind us is the steep slope which we have ascended, and which stretches down to the border of the Mer de Glace. This crest on which we stand is "The Angle," and, ever narrowing, leads up to the pillared and snow-flecked heights of Charmoz. That is our direction. But mighty rocks and towering precipices obstruct our path. Some of the precipices we have to scale. Sometimes we crawl along the face of an escarpment upon a shelf of rock gradually ascending to the summit. Sometimes from such a situation we are compelled to retreat. Could we see each other in these hazardous attitudes, I fear we should be led to practice eloquently the art of dissuasion; and could those patient ladies, pressing Alpine flowers at Montanvert, be once endowed with the gift of clairvoyance, I am sure that some of us would make excuses to return.

But adventure acts as an intoxicant. We often perform deeds without fear, the very thought of which afterward produces a shudder. We have the madness — not the malady — of the mountains. And so we continue to climb toward Charmoz. Ice on the right hand; ice on the left ; clouds above us and clouds below. The ragged crest grows narrower, its downward slopes more precipitous. Charmoz is in front of us and winks approval of our hardihood. Stiff-necked, haughty pinnacle, uplifted in the serene air! what power upbore you to that unapproachable altitude? Ah, the answer to our question is recorded on your grey, pilastered sides. If we cannot place foot upon your head, we are near enough to read your record. We can see your vertical sheets of rock, with their projecting angles running up the giddy spire like the lines of masonry on the high-towered cathedral at Strasbourg. Old Charmoz, after all, is not erect, but prostrate on his side. Weathered and battered and wasted by the wear of centuries, these salient pinnacles are but the protruding ribs of a mountain skeleton.

We have discovered the way to Charmoz, but, like Jacques Balmat, on the discovery of the path to Mont Blanc, we shall not travel over it the first day. Our mountain crest which leads to Charmoz has thinned to a knife-edge. On each side we look down, almost vertically, about two thousand feet, upon some rocks which would have a tendency to abate too suddenly our agreeable excitement. We know that we could scale the pinnacle of Charmoz, but we ought to go back and inform the ladies where we might be found in case of any inadvertence.

But we shall not travel the same road twice. We descend a declivity as steep as possible, directly to the Mer de Glace. Getting in the track of an old avalanche, we go plunging, sliding, jumping, rolling,— and so, literally, "we go rolling home." Reaching the glacier, we mount its tremendous lateral moraine — rising one hundred feet above the swelling ice-sea ; and over boulders, and along the shining faces of cliffs scoured by the moving ice, we pick our way down to the spot where we left the ladies pressing flowers.

We now feel competent to cross the Mer de Glace without the intervention of a guide. Declining many proffers of succor from this source, we make our zigzag descent two hundred feet (210 feet) to the glacier. Half way down we encounter a cabin, wherefrom, with further proffers of guidance, is exposed a collection of pretended minerals of Mont Blanc,— quartz and tourmalines and amethysts and beryls. Assured again of the utter impossibility of crossing without a guide, we persist in suspecting the disinterestedness of the counsel.

The border of the glacier presents an array of obstacles which had been concealed from view. It is a great mistake to suppose that the entrance upon a glacier is like stepping from the sidewalk into the street. Here is a belt some rods in width, possessing features which defy description. It is strewed with immense rounded fragments of alpine granite, with intervening piles of sand and mud and ice and smaller rocks. To thread our way between the boulders is impossible,— we must leap the chasms from boulder to boulder, or climb directly over them. Considering that these impediments are breast high, and sometimes eight and ten feet high, and round and smooth, the degree of agility demanded is as extraordinary as it is real. Next we leap upon a boulder which proves to be a mass of ice coated with sand and mud. Nay, the very soil on which these boulders rest is underlaid by ice as solid and clear as crystal. Down we leap, upon the grimy surface of the glacier at last, but only to find ourselves in a corner. Across our path stretches an open chasm which is almost too broad to leap, and which is overhung on right and left by huge boulders. There is no alternative ; we must mount another boulder ; and so, finally, after a wearisome struggle, we are in a position to begin our work.

Well, the glacier is under our feet at length. It is the Mer de Glace. We read of this wonder of nature when we were boys in school, and puzzled over the poor uninterpretable pictures of it in our text-books. It is not so rough and rent with fractures as we had thought. The path winds over its wave-like swells and around its yawning crevasses; and we march on, thinking of the depth of the river of ice on which we walk; of its sluggish, crawling movement down toward the valley of Chamonix; of the years which have rolled by since the ice under our feet was fresh-fallen snow on Mont Mandit; of the terrific winter storms which howled about the cradle of the glacier; of the deliberateness of all of Nature's operations. And then we reflect how all this work was going on before we were in existence; and how, when *we* shall have ceased to appear among men, Nature's operations will experience no check, but continue to move on in their appointed ways, steadily, patiently, while other generations of men may come and go. Here, far from the glacier's border, are fragments of rocks riding in state upon the glacier's back, down from the region of some high alpine cliff, toward the precincts of human habitation. These, like the boulders of the border, are formed of that peculiar species of rock which constitutes the core of the Alpine chain. Here, now, are those crevasses which create so much of the peril of glacier adventure. The crevasse is a fissure in the mass of ice. Its direction on the surface is generally transverse to the axis of the glacier, or approximately so. In length it may vary from twenty feet to a mile. Its downward direction is originally vertical; but as the surface of the glacier moves more rapidly than the lower portions, it assumes, after awhile, an inclination which gives it a dip up the valley. Its depth may be ten or a hundred feet, and its width, which is a few inches at first, may grow to fathoms.* The two walls generally approach each other downward, and we may sometimes safely descend to the bottom. The wall-ice is absolutely immaculate, with a greenish-blue transparency. Down in the crevasse we hear the rills coursing through the substance of the glacier, and sometimes the central torrent rumbling along the bottom. The surface of the glacier is white and granular from the action of the sun. Pools of water rest here and there,—pure, cold and refreshing,—and numerous rills flow over the surface, discharging themselves through perforations in the ice-mass, into some subglacial stream.

All goes well. Now we reach the median moraine, which, from Montanvert, we had mistaken for the opposite side. This is a longitudinal ridge of icy fragments and commingled boulders and sand. The remaining half of the glacier is strewed with rocks and glacial débris. Now the real difficulties begin. The crevasses grow into immense yawning chasms, and the ice-masses between them rise up like mere knife-edges, on which one must balance himself in the transit. The mutual intersections of these crevasses continually interrupt the pathway, and we are compelled sometimes to descend by a series of ten or twenty steps cut in the ice by the guides, and then to ascend by as many more. We cannot disguise the fact that the element of danger enters into the passage of the Mer de Glace; but with it comes the exhilaration and the determination to accomplish the transit without a guide. If worst comes, there is a man hanging upon our heels, expecting that the next moment will find us suing for his assistance. The peril arises from the absence of any discernible path, and our ignorance of the route indicated as easiest by the continued experience of the guides.

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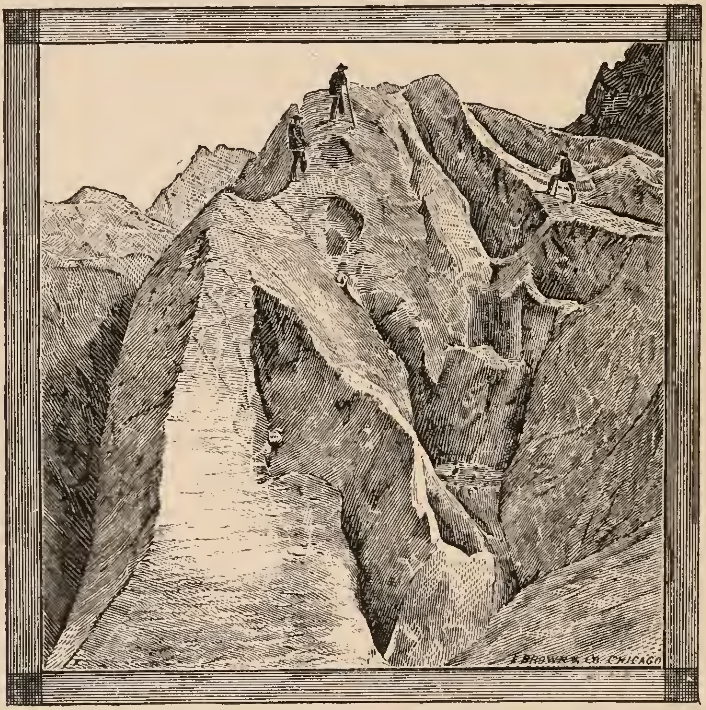
* In 1824, Forbes measured a crevasse at the base of the Glacier du Géant which had a breadth of not less than 1214 feet (370 metres). Payot, *Guide Itinéraire*, p. 146, note.



DIFFICULT PASSAGE ON THE MER DE GLACE. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

The farther border is reached in safety,—if there be any border-line between the ice and the earth into which it graduates by insensible degrees. Another contest with huge boulders of protogine, and we strike a path which leads us steeply through a mire of sand and dust to the crest of the great lateral moraine, from which we look down a hundred feet upon the billowing glacier with a feeling of exultation not unmingled with gratitude. The Mer de Glace is, after all, a mile and a quarter in width at this place; and we feel divested of some portion of the contempt with which we greeted its first appearance from the inn at Montanvert.

Instead of recrossing the glacier, we descend along the moraine. Soon the sound of water reaches us. Suddenly we stand in the presence of a most magnificent cascade. The Nant-Blanc, a mountain torrent from a glacier of the same name (lying between Aiguille Verte and Aiguille Bochard), comes literally bounding, skipping, leaping, summersaulting down the steep ravine a mile in length, and at last jumps madly off the precipice at our right, and, striking on the chaos of rocks, breaks itself into millions of pieces. I have seen nowhere a more satisfactory performance of aquatic gymnastics. Irresistibly one recalls Southey's description of "The way the water comes down at Lodore."

"Recoiling, turmoiling and toiling and boiling
And thumping and flumping and bumping and jumping
And dashing and flashing and splashing and clashing,
And so never ending, but always descending,
Sounds and motions forever and ever are blending.
All at once and all o'er, with a mighty uproar,—
And this way the water comes down at Lodore."

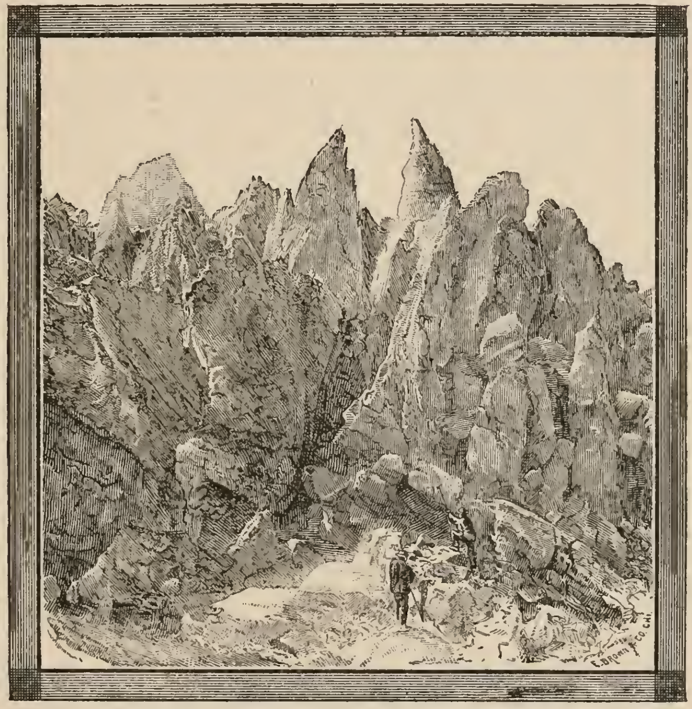
We had seen this torrent of foam from the opposite side, lying upon the steep slope of the mountain like a white line. It is said that sometimes boulders disengaged by the melting ice of the glacier, which feeds the torrent, ricochet along in company with it, and leaping from the precipice, endanger the safety of the rapt spectator of the scene.

A short distance below we encounter another "nant" dancing down in a gentler mood.

The moraine on which we travel is an immense ridge of boulders and pulverized rocks. On our right it descends from thirty to fifty feet, forming a little valley between us and the contiguous mountain. On our left the descent is from fifty to one hundred feet to the surface of the glacier. On this side the elements are causing the moraine to crumble away, and many a land-slide has made it necessary to change the location of the tourist's path. The material is deposited upon the glacier, and enters into the formation of a new and smaller moraine, corresponding to the present stage and condition of the glacier. It is evident that this great moraine is gradually disappearing. It is equally evident that when it was formed the glacier filled the valley a hundred feet higher than at present. And the polished rocks of the mountain wall further evince that at some period antecedent to the creation of this great moraine the ice rubbed the sides of the mountain at altitudes a hundred and fifty or two hundred feet above the existing ice-level.

Our moraine, as we advance, grows thinner, and now it fades out against a steep sloping wall of (schistose) rock, along which we pass, rapidly descending, by means of steps cut by the guides. To add to the voyager's security, an iron rod, bolted at intervals to the cliff, extends from end to end of this descent. This is the Mauvais Pas. Midway of the passage, a flock of goats skips past us as if wholly unconscious of any difficulty in the path, and after them skips the shepherd-boy, with a similar unconsciousness.

Before reaching the Mauvais Pas, the Mer de Glace changes its name to Glacier des Bois. The slope of its bed becomes more rapid, and the crevasses yawn more deeply, more numerously, and more irregularly. The huge crests of ice, cut across by other crevasses, become converted into immense pyramids and needles of ice, which bristle like porcupine quills over the greater part of the surface. Those which assume a more columnar form are locally known as séracs. Looking down upon



ICE NEEDLES OF GLACIER DES BOIS, THE LOWER PART OF THE MER DE GLACE. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

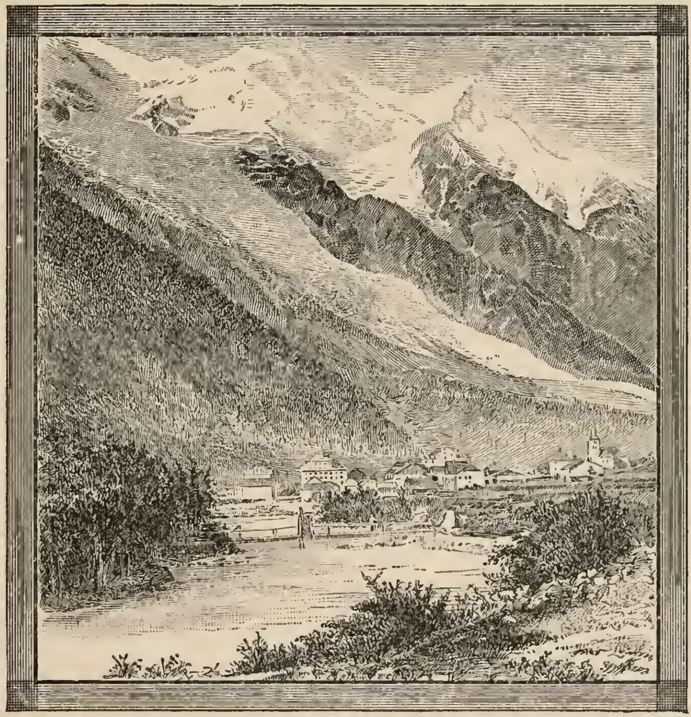
the Glacier des Bois from the Chapeau, the whole aspect of its surface is wild and chaotic beyond expression. Immense boulders lie scattered up and down, and the whole surface is gray with gravel and sediment. Here and there large pools of water have accumulated in the depressions of the ice, and numerous streams descend into the depths of the crevasses,—gurgling, rumbling and rushing on to join the great trunk drain of the valley. We stand and gaze with admiring amazement at the tremendous features of this icy mêlée. We ask the glacier's pardon again for our depreciatory greeting.

The Chapeau is found hanging on the cliffs at the foot of the Mauvais Pas. It is a mere cave-like recess under an overhanging rock. Here is a beautiful spring, which is utilized by the occupants of a miserable cabin,—a cabin not too miserable to extend its offer of *rafraîchissements* to the passing tourist.

At the Chapeau we strike a path practicable for mules. After traversing a forest of firs (Bois du Bouchet), we burst upon an outlook as charming as it is unexpected. Mont Blanc and his companions stand out in sunset illumination, presenting a spectacle different from any yet witnessed. We are still several hundred feet elevated above the vale of Chamonix. On the side opposite us rise the Flegère and the Brévent, and back of these the Aiguilles Rouges. The shadow of these mountains has spread its gray mantle over the valley, but the silver forms of the monarch domes on the side facing the declining sun are dazzling in a radiance which is brilliant but majestically serene. Glancing up the valley of the glacier, the white pinnacles of ice first arrest the eye, and then it rises to the illumined spires of Aiguilles du Dru, de

Charmoz and de Greppon, and to the right of these loom up the bright summits of the Blatière, the Midi, the Mont Maudit, which from this point masks the crest of Mont Blanc, and the Dome and Aiguille du Gouter, lifting themselves upon the shoulders of Mont Blanc.

We pause here to enjoy the changing aspects of this magnificent scene. The Mont Blanc mass rises before us



CHAMONIX AND MONT BLANC FROM NEAR THE FOOT OF THE GLACIER DES BOIS. THE ARVE AND THE VILLAGE OF CHAMONIX, WITH BASE OF THE MONTANVERT ON THE LEFT. BEYOND IS THE GLACIER DES BOSSONS DESCENDING FROM THE SUMMIT OF MONT BLANC (NOT SHOWN). TO THE RIGHT OF MONT BLANC IS THE DOME DU GOÛTER, AND NEXT THE AIGUILLE DU GOÛTER. IN THE VALLEYS BEYOND THE GLACIER DES BOSSONS ARE THE GLACIER DE TACONNAY AND THE GLACIER DE LA GRIA. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

majestic, lofty, silent and serene. Its ponderous form reaches downward into the evening obscurity of the valley. The boundary line between the light and shade is concealed by a belt of carmine-tinted clouds, sleeping lazily on the bosom of the mountain. The effect is to isolate the glorious heights from the dusky terrene landscapes lying below. The mountain rests in its frame of clouds, as beautiful as Clytie in her sunflower. Its snowy surface gleams with a luster of brilliant silvery whiteness. But while we gaze we discern a change. It is like the changes which pass over the aspects of the heavenly bodies. The sable brush of night has dulled the roseate tinge of the wreath of clouds. A golden yellow film has been drawn over the silvery whiteness of the mountains. Now a rosy flush displaces the tint of gold,—as if some evening camp-fire had been lighted to replace the warmth of the retiring sun. Sooner than our thought, a cerulean tint steals over the scene, which, dissolving with the red, throws over the gigantic form of the mountain a robe of imperial purple. But immediately the luster of the purple mantle fades into a dusky, silver-gray; then an ashy paleness flits for an instant over the scene, and the light of day has left Mont Blanc to his proper complexion,—a pure snow-whiteness veiled in evening shadow, and resting against the deep cerulean beyond.

The glacier which we have visited presents still one scene of impressive and suggestive grandeur. We must visit the glacier at its termination. Devoting an afternoon to the trip, we find the little hamlet des Bois situated at the foot of the stupendous terminal moraine, the outer slope of which is occupied by scattered firs. Passing through an opening excavated by the Arveiron, which takes its rise from the glacier, we are ushered into an amphitheater, the vastness of whose proportions and the utter chaos of whose aspect create a feeling of oppression in the mind. The moraine is at least eighty feet high, and sweeps around in front of us to join the lateral moraine. It is a desolate pile of clay and sand and rounded boulders. Its inner slope is interrupted by another moraine thirty feet high, which, like a bench, extends from end to end of the circuit. This immense terraced wall incloses an area nearly half a mile in each diameter, and strewed with a wilderness of granitic blocks, among which we pick our way. The white water of the rushing stream, which deafens us with its din, pours out from beneath a dark majestic vault of ice in the lofty terminal wall of the glacier. This is the source of the Arveiron,—an insignificant though noisy river, blending, in the course of a mile, with the equally turbulent Arve. But how magnificent is its cradle! With difficulty, and not without danger, we climb over the débris to the very foot of the glacier and lay our hand upon the cold ice. Beyond and above us stretches the icy river, with its bristling pyramids and needles projected against the sky. A chilling current of air from the surface of the glacier settles down upon us. Rocks of granite and rocks of ice are mingled in indifferent confusion beneath our feet, upon our right and upon our left, while, from moment to moment, the blocks which have completed their long journey upon the back of the glacier, dismount with a plunge which startles the visitor and prompts him to reflect upon his danger. A few years ago one of these missiles crushed the cranium of a young English lady and threw her into the torrent. Two other fatal accidents of this kind have occurred, besides several severe contusions. Some years ago three tourists tried the experiment of exploding a bomb beneath the vault of ice. The arch came tumbling about their heads; one was crushed to death, and the two others were very severely wounded.

The movements of the glacier are among its greatest marvels. It marches and it retreats. The Lower Glacier of the Aar, which was the scene of Agassiz' observations, moves downward at an average rate of 250 feet per annum (Dolfuss-Ausset). Hugi's hut, according to Agassiz, had been carried 5,900 feet in 13 years. A record bottled up by Hugi, stated that it had traveled 197 feet in three years and 2,345 feet in 9 years. The Mer de Glace travels better. Forbes demonstrated by observations that at Montanvert it moves 822 feet per annum, and at the source of the Arveiron 209 feet per annum. The stream of ice, pressed into a narrower channel, moves with increased velocity.

This march of the glacier, unless counteracted, would result in a rapid encroachment upon the cultivated lands of the valley. The compensation is found in the summer's warmth. The ice undergoes a rapid dissolution,—as the river testifies which issues from its base. This causes a diminution of the glacier in a longitudinal as well as a vertical sense. The advance of the lower extremity is melted off during the summer. If the season prove unusually warm, the dissolution exceeds the advance, and a retreat is the net result. If the season prove cooler than usual, the advance exceeds the amount of dissolution, and the resultant is a net advance.

Now, it is apparent that this glacier before which we stand, has formerly occupied a more advanced position.

A record on a stone at the outer moraine informs us that this epoch was 1826. At that time, says Payot,* the terminal moraine had been crowded close to the little hamlet des Bois, to the great consternation of its inhabitants, and some huge blocks, still to be seen, were hurled down among the houses. From that date to 1869 the retreat had amounted to 1,640 feet. In the same time, the vertical thickness of the glacier has diminished 984 feet. There rises before us an immense protrusion of rock, standing exactly in the natural course of the glacier. Its surface is planed completely smooth, and the guides tell us that within their memory the river of ice flowed triumphantly over it. Now it turns to the right, and describes a semi-circle to avoid the obstacle.

Let us now view these objects from the opposite side of the valley of Chamonix. The ascent of the Flegère is one of the favorite excursions. It is only six thousand feet high, being a little less elevated than Montanvert. The path is similar, and the scenes are similar. From the inn on the summit we obtain magnificent views of the whole chain of Mont Blanc. The Mer de Glace winds snake-like down its valley, and the needled pinnacles surrounding its upper course stand forth in characteristic boldness. We have more than once remarked the contrast in form between the aiguillated summits and the rounded dome of Mont Blanc. A difference in geological structure is, of course, the cause of this. A geological section, across any part of the Alpine chain, shows it to be constituted of three portions,—a Middle Zone, a North Lateral Zone, and a South Lateral Zone. The rocks of the Middle Zone stand almost vertical, while those of the

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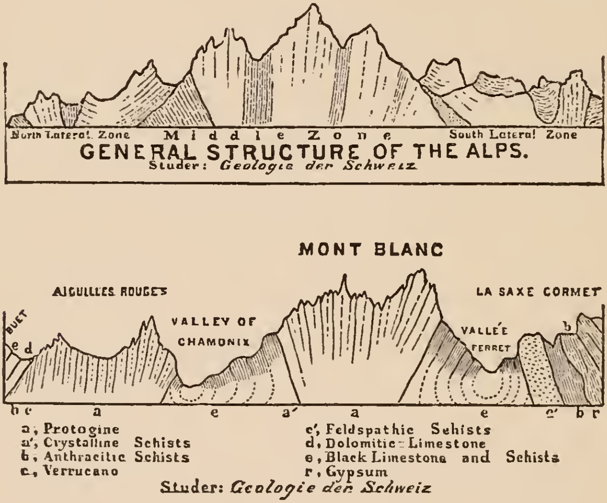
* Payot, *Guide Itinéraire au Mont Blanc*, p. 153.

Lateral Zones are much less tilted, and seem to have been displaced by the up-thrust of the Middle Zone. All the rocks which we have observed belong to the Middle Zone; but in this zone is a huge central mass of unstratified Alpine granite, or protogine, constituting the loftiest summits of the chain,—Mont Blanc, Monte Rosa, Bernina, Jungfrau, Finsteraarhorn, and others,—while the contiguous portions, on either hand, consist of masses of vertically stratified schists,—as we have seen in Aiguille de Charmoz, Aiguille du Dru and other pinnacles.* By weathering, these projecting strata assume the castellated forms so magnificently displayed from the Flégère. The unstratified protogine, on the contrary, weathers into the class of rounded forms of which Mont Blanc is the type. It is from the loftier "central mass" that the boulders of protogine so abundant along the paths of the glaciers have been transported.


North Lateral Zone
Middle Zone
South Lateral Zone
GENERAL STRUCTURE OF THE ALPS.
Studer: Geologie der Schweiz
MONT BLANC
AIGUILLES ROUGES
LA SAXE CORMET
BUET
VALLEY OF CHAMONIX
VALLÉE FERRET
e d b
b c a e a′ a e c′ b r
a, Protogine
a′, Crystalline Schists
b, Anthracitic Schists
c, Verrucano
c′, Feldspathic Schists
d, Dolomitic Limestone
e, Black Limestone and Schists
r, Gypsum
Studer: Geologie der Schweiz

STRUCTURE OF THE ALPS OF CENTRAL EUROPE.

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* Studer, *Geologie der Schweiz.*

From the Flégère there is a path to the Brévent, without descending to the valley of Chamonix. We must visit the Brévent, because from that position we obtain the most intelligible view of Mont Blanc and its surroundings, and look down upon the Glacier des Bossons, as, from the Flégère, we look down upon the Mer de Glace. Here, from the summit of the Brévent, how magnificent a panorama is spread before us![†] Directly in front is Mont Blanc; on the right is the Dome du Goûter with the little protuberance called the Dromedary intervening. Further to the right is Aiguille du Goûter. To the left of Mont Blanc is Mont Maudit, separated by a depression called the Corridor. The angular summit to the left of this is Mont Blanc du Tacul. This wide expanse of mountain summit is deeply covered with ancient snows in the granular condition called *névé* by the French and *Firn* by the Germans. This exists everywhere at elevations above 10,000 feet. The firn-fields are the aliment of the glaciers. When they descend below the altitude of 10,000 feet the softening influence of the sun causes the firn to be converted into ice. Above the firn-fields rise dark masses of rock whose slopes are too steep to retain the snows. We note in particular the Grands Mulets, two rocky pyramids, on one of which the guides have erected an inn for the accommodation of voyagers in the ascent of Mont Blanc.

From this enormous firn-field two great glaciers are seen to descend, separated by the "comb" of the mountain. We have seen both of these when first entering the valley of Chamonix. The larger one on the left is the great Glacier des Bossons, and the other is the Glacier de Taconnay. Note, from this point, the terminal moraines which have accumulated about their lower extremities. No argument is needed to convince us that this work was accomplished by a more developed condition of the glaciers than we witness to-day. Payot* tells us that the maximum advance of the Glacier des Bossons, in modern times, was in 1817. From that date to 1869 it had retreated 1,800 feet, and had suffered a lowering of at least 300 feet. In 1817 the terrified inhabitants of the little village at its foot held devotional processions, and planted a cross in the path of the glacier to impede its march. Happily the advance was checked, and the devout bourgeoisie have room for the belief that processions and crosses have turned the course of Nature.

[†] See the view, p. 65.

As we stand contemplating the grandiose features of the scene before us, we feel arising a strong ambition to be among the number of those whose feet have rested upon that white mountain dome. We must undertake this thrilling experience on some other occasion; but, lest we be wholly defrauded of this pleasure, we will make a preliminary ascent over the first section of the route. This will take us to the upper reaches of the Glacier des Bossons.

Ascending from Chamonix, our first halt is at the Cascade du Dard. A small stream of ice-cold water breaks itself in pieces in coming down a cliff some 60 feet in height. The path leads past another fine cascade (des Pelerins) and along the brink of a precipice overhanging the valley of the glacier, from which, five hundred feet below us, we look down on the stream of ice. Passing the upper limit of trees, we pursue our zigzag path to

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* Payot, *Guide*, p. 149.

Pierre Pointue, 6,722 feet above the sea. Here is a comfortable little inn, whose keeper, Sylvain Couttet, has become well known to ascensionists.

After rest and refreshment, we press on toward the border of the upper Glacier des Bossons. Overcoming the difficulties which everywhere beset the entrance upon a glacier, we traverse the plateau of the glacier, and proceed as far as its junction with Glacier de Taconnay. The expanse of ice and snow is wild and chaotic beyond description. Enormous crevasses, precipices to be scaled by means of ladders, towering pyramids, beetling séracs and bristling needles of ice, succeeding each other mile after mile,— these must be seen to be appreciated or understood.

But here, for the present, we check our roaming, and take leave of the majestic forms and sublime silences of these awful Alps. There is much more here than the material lineaments which address themselves to the literal eye. To him who has cherished and cultured the divine gift of penetrating beyond the visible forms of Nature, there is a realm of meaning revealed by these stupendous features which, to grosser eyes, they completely obscure. It was in this vale of Chamonix that Coleridge penned his "Hymn before Sunrise," so full of the spirit which transfuses Nature. To the poet, realities unseen and truths unutterable are proclaimed by "those five wild torrents fiercely glad," called forth from the "icy caverns of night and utter death"; by their "unceasing thunder and eternal foam"; by the "living flowers that skirt the eternal frost"; the "wild goats sporting round the eagle's nest"; the "lightnings, the dread arrows of the clouds," and first and chief, the snow-clad "sovran of the vale," with sunless pillars sunken deep in earth, and countenance filled with morning's rosy light.

"Thou too, hoar Mount! with thy sky-pointing peaks,
Oft from whose feet, the avalanche, unheard,
Shoots downward, glittering through the pure serene
Into the depths of clouds that veil thy breast,—
Thou too, again, stupendous mountain! thou
That as I raise my head, awhile bowed low
In adoration, upward from thy base
Slow traveling with dim eyes suffused with tears
Solemnly seemest, like a vàporing cloud,
To rise before me,—Rise, oh, ever rise,
Rise like a cloud of incense, from the Earth!
Thou kingly spirit throned among the hills,
Thou dread ambassador from Earth to Heaven,
Great hierarch! tell thou the silent sky,
And tell the stars, and tell yon rising sun,
Earth with her thousand voices, praises God."

ASCENT OF MONT BLANC.

THE ascent of Mont Blanc is an achievement which constitutes an epoch in a human life. It is one of the most glorious and memorable experiences which it is possible to gain. The conditions of this consummation are fatigue and danger; but these are also the conditions of that inspiration which scorns obstacles and is blind to everything but its object.

I cannot assert that, to all who make the ascent, a love of nature's sublimities is the source of this inspiration. Some scale the glaciers and the snows of the mountain because it has become somewhat of a fashion; and to follow the fashion there is no extreme of discomfort or fatigue they will not endure. Some make the journey because, wearied with the common-places of travel, there is no other place to go,—Mont Blanc is their refuge from *ennui*. Such persons climb over eternal snows, to the voiceless solitudes of mountain summits, in the spirit of the teamster, who undertakes to haul you a hundred perch of quarry-stone. It is a job which must be accomplished,—*that is all*.

For us, the inspiration which we feel proceeds from a kindled imagination, inflamed by the pleasing but terrible majesty of the forms of Nature which surround us, and which seem scarcely to veil the personal majesty of the Supreme Creator himself. It is not so much in the view from the summit of the mountain; for this is disappointing. The entire landscape has been spread before us for hours before attaining the highest dome. There is something in standing where so few feet have stood before; and one can enter fully into the ambition of the Englishwoman who compelled her guides to hoist her on their shoulders, that her head might be higher than any other mortal's who ever stood on the summit. There is a fullness and completion in the satisfaction felt by one who has reached the very dome; but all which thrills, all which swells, all which ennobles the soul, is met and felt long before the final consummation of the ascent. The summit, therefore, brings a flush of disappointment. The landscapes beneath are distant, and flat, and dim. The object which inspired your veneration and fixed your ambition no longer rises before you; it has ceased to exist; your ardor subsides, and you feel almost impatient to descend. De Saussure relates that such was his own chagrin, on reaching the summit after years of effort, that he stamped his foot in a sort of anger. Forewarned, we shall not be disappointed.

Mont Blanc, I have said, is a sort of fashion; but, to say it is the fashion, is to say it has not been long in vogue. As a fashion, it may be said to have taken its rise in 1861; though the first ascent was three-fourths of a century earlier; and the first tour of the Alps for the observation of Nature was in 1741. The Alps, indeed, have been imperfectly known since the time of the Romans, who have left many traces of their occupancy in the form of tunnels, and excavations for highways, and half-obliterated exploitations for the useful metals, and even a single inscription found in the descent from the Col de Forclaz to Saint Gervais. In 1090 a priory or convent of Benedictines was founded in the valley of Chamonix, which, in 1330, made laws against foreigners, and which, after 1443, received frequent visitations from the bishops of Geneva. In the seventeenth century it seems that the glaciers were in process of advancement; and the simple and pious people of the valley — then, and a century afterward reputed a set of brigands — felt a strong anxiety that their aged bishop should exorcise them. As the Bishop, Jean d'Arenton, was very aged, and lived at Annecy, forty miles distant, they grew apprehensive that death might deprive them of his services. They therefore sent a deputation and implored him, in all sincerity, to come and intervene in their behalf. Touched by their simple faith, the aged bishop went and "exorcised and blessed those mountains of ice." The historian states that from that time the glaciers retreated; and a hundred years afterward (1767) had left an interval of a third of an English mile between them and their ancient limits.*

As the English have always been the most numerous frequenters of the valley of Chamonix, so it was a company of Englishmen who first visited the valley in the character of tourists. In 1741, two Englishmen, Windham and Pococke, with seven compatriots and a large number of servants, set out from Geneva, "armed to the teeth," and supplied with tents and provisions for a long and hostile campaign. After three days they entered the valley, found the inhabitants unexpectedly peaceful, accepted their hospitalities and offers of aid, and ascended the Montanvert and surveyed the great glacier which flows at its feet. Windham, in a subsequent account, compared its surface to that of an ice-floe in a Greenland sea; and from that time it has been known as the *Mer de Glace.* This company, it amazes us to learn, now felt their curiosity gratified, and marched back to Geneva. Another expedition was made the following year, by Martel of Geneva, who effected an approximate measurement of the height of Mont Blanc.

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* *Vie de Jean d'Arenton d'Alex*, Lyons, 1767.

The apathy of some souls in the presence of Nature's sublimities is to me as incomprehensible as the darkest of Nature's mysteries. Windham had discovered a new world,—I had almost said he might have become the apostle of a new worship. But he goes home from the august presence of Mont Blanc and its gigantic glaciers and writes: "However savage these regions may be, one does not fail to find here at times some very beautiful landscapes." I quote from one of Durier's lectures on Mont Blanc, delivered in Paris, the comment of a susceptible mind on such a degree of coldness. "Clearly," he says, "this is not the tone which the subject demands. You feel that, at this distance. There exist here many shabby glaciers, of villainous aspect; rocks which reveal nothing of value; precipices to make one shudder; torrents on whose borders one cannot hear himself speak. But, God have mercy! you find here and there some villages agreeably situated; fine meadows; fields well cultivated, and clusters of trees producing happy effects. Ah! my friends, I have waters, and meadows, and hamlets and woods at my very door,—why go so far to seek them?"

In Horace Benedict de Saussure was a different soul. Born in Geneva, the spirit of the Mountains seems to have been inherited in him. From gathering wild flowers to soothe the weary hours of a sick mother, the child began to stroll to the neighboring mountains. He had looked upon them with an inspiration, a longing, a worship. While yet a boy, he had scaled the cliffs of the Great and Little Salève; he had wandered over the ranges of the Voirons; at nineteen, he spent fifteen days among the loftiest summits of the Jura, and, the same year, ascended the Môle. From all these altitudes, the majestic, snow-covered summits of the Mont Blanc range were ever before him, and he burned with a desire to scale them. In 1760, at twenty years of age, he proceeded on foot to Chamonix. Thereafter, for many years, he performed an annual pilgrimage to the Alps. He ascended most of their lofty summits, as well as those of the Apennines, the Jura, the Cevennes, the Cote d'Or, the Vosges, the mountains of Sicily, the Auvergne, England and Germany.

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* Durier, *Histoire du Mont Blanc*, p 32.

But Mont Blanc impressed him more profoundly than all these. And yet its dazzling dome had repelled all attempts to scale it. De Saussure was a scientist. What aid might be derived from its summit in determining the general configuration of the Alps! What interesting studies of the world of glaciers!—of the temperature, and the effects of atmospheric rarefaction at such an altitude! De Saussure felt that he *must* reach the summit of Mont Blanc. He cherished the purpose for twenty-seven years. He made repeated efforts to overcome the obstacles of nature, but always failed. And yet, from every hill-top — from his very study window at Geneva — the calm, mild visage of the unsubdued monarch smiled triumphantly upon him. He nourished his defeated ambition till he gazed upon Mont Blanc with a sort of frenzied, painful pang of disappointment. But this was not despair. He offered rewards to the peasants of Chamonix for the discovery of the way to the inaccessible summit. There were many whom the hope of gain impelled to perilous endeavors,— one whom the spirit of de Saussure had inspired with a noble and strenuous ambition. The force of soul succeeded where cupidity had failed. Jacques Balmat, in 1786, climbed bravely to the summit, and stood where human foot had never been placed before. It was only during the next year, however, that De Saussure himself was enabled to follow Balmat to the summit and institute the long-sought scientific observations.*

I shall not detain the reader with further preliminaries. I hope his appetite is keen for the experiences to which I invite him. Will he go with me over those frightful fields of ice,— those yawning gulfs,— those dizzy cliffs,— those glassy slopes? Will he venture on those broad plateaux of eternal *neige*; and, braving cold, and clouds, and snows, and lack of breath, aspire to place his feet where Balmat stood,— before the eyes of four nations — France and Switzerland, Germany and Italy?

Let us, then, seek first a panoramic view of the region which is to be the scene of our labors. A hundred summits gaze full in the face of the snowy monarch of mountains; but there is none which faces him so squarely and so boldly as the Brévent. This mountain belongs to the range of the Aiguilles Vertes, on the side of the valley opposite the Mont Blanc group, and the visit to it is one of the favorite excursions from Chamonix. If a view more magnificent or awe-inspiring exists on any part of this planet, I have no idea where it lies. We are looking southeast. Here, in the center of the field, rises the majestic dome of Mont Blanc. Though remoter than any of its neighbors, it overtops them all. To our right are two principal summits swelling from the mountain mass. The first of these is the Dome du Goûter, separated from Mont Blanc by a minor swell called the Hump of the Dromedary. The other principal summit is the Aiguille de Goûter, with a sharp crest striking obliquely down the mountain. To our left of Mont Blanc are two principal summits. The first of these, with the brown ragged

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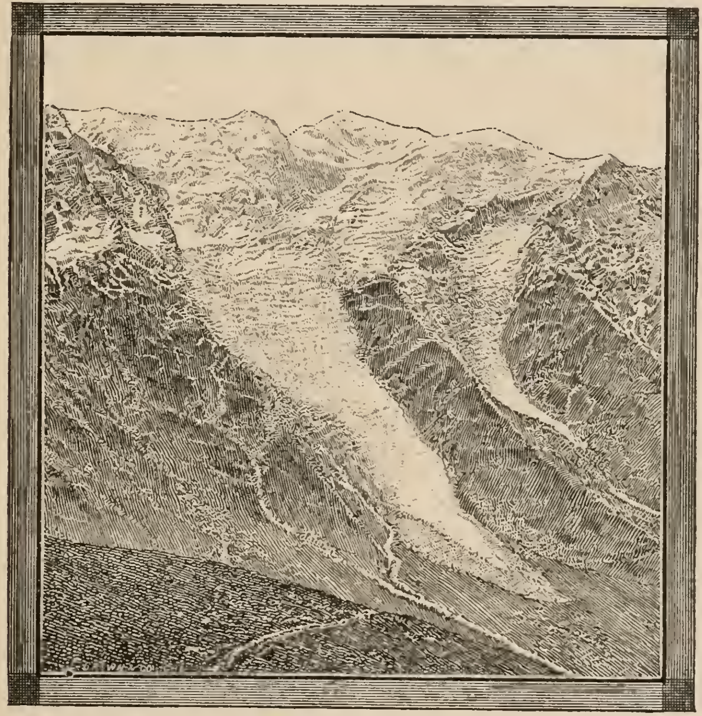
* De Saussure, *Voyages dans les Alps*, 4 vols., 4to.



VIEW OF MONT BLANC FROM THE BRÉVENT. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

front turned toward Mont Blanc, is the Mont Maudit or Cursed Mountain. This entire range, in the middle ages, was known as the "Montagnes Maudites." They were cursed with eternal snows and sterility in punishment of the sins of the inhabitants of the region. So, at least, other people alleged. Thus, also, in the Pyrenees, the loftiest summit is "Maladetta."

The principal summit to the left of Mont Maudit, and apparently separated from it by only a shallow depression, is the Mont Blanc du Tacul. Close observation will show, however, that the mass to which this summit appertains is quite separated from Mont Maudit by a col or depression, and that its right-hand termination, instead of being Mont Maudit, is an obtuse mountain angle between the two. This is Aiguille de Saussure. Farther to the left, and more in the foreground, are the Aiguilles du Midi. On the northern slope of Mont Blanc we notice two dark ranges of rocky cliffs. These are the Rochers Rouges or Red Rocks.

From right to left this extensive field is mantled with ancient snows, which have mostly assumed the granular condition known as "firn" or "névé." These are the storehouse of glacier material. In places where the mountain surfaces are too precipitous the bare rocks protrude. The field of névé in general undulates in conformity with the configuration of the mountain face; but in some places we trace perpendicular cliffs of snow, one or two hundred feet in height. One of these, starting from near the crest of the Aiguille de Goûter, angles like the bastions of a fortification across the upper limit of the great Glacier de Taconnay. Another snow-wall is revealed, stretching from the foot of Mont Maudit, and still others overhang the cliffs of the Rochers Rouges. The larger of the two enormous glaciers which constitute the outlets of this vast sea of névé is Glacier des Bossons, which is separated from the other by a wedge-shaped crest of rocks, terminating upward in the spires of Aiguille de la Tour. Rising from the firn-field, in the direction pointed out by this rocky crest, we see a series of sentinel-like pyramidal rocks standing in dreary isolation. These are the "Grands Mulets" or Big Mules. On the lower one the guides of Chamonix have erected a couple of cabins, which serve as inns,—plain, and even rude; but never was inn entered with fewer questions asked than this, after a desperate scramble of six hours' duration.

In gazing upon this panorama of glaciers, one cannot fail to remark the immense moraines accumulated about their lower reaches. The great elevations of these moraines are due to the agency of a flood-time in the glacier stream. Sixty-four years ago (1817) the valley of Bossons was 300 feet fuller than at present, and the ice-stream stretched a third of a mile farther down the valley. It will be noticed that these moraines continue far up the sides of the glacier. Let me ask the reader to note what seems a vast notch in the northern margin of Glacier des Bossons. A huge protuberance of rock deflects the glacier to the south. Formerly the ice river flowed over this obstacle. I have stood on the polished surface which bears this testimony. A vast amount of moraine material has been piled up at the foot of this huge precipice,—for huge it is, though at this distance appearing somewhat insignificant. Farther up is another notch, of smaller dimensions, produced by a similar cause. Tame as the features of that spot may appear from the Brévent, eight miles away, I assure the reader that here exists a spectacle of awe-inspiring sublimity. A lateral portion of the glacier terminates here abruptly. Below is a smoothed slope of rocky surface, at the foot of which yawns a profound transverse gulf, beyond which, looking down the mountain, rises, to the altitude of fifty or sixty feet, the rocky mass which obstructed this section of the glacier. A torrent rushes from a cavernous opening at the foot of this glacier segment, and, roaring down the smoothed declivity, plunges with headlong madness into the dark gulf,—dashing itself into a white mist, which rises like a liberated spirit toward heaven. While we stand here, awed by the tremendous voice of the waters and the majesty of the bristling mountain of ice which rises above us, huge boulders, loosened from the glacier's front by the afternoon sun, come crashing and ricocheting past the spot on which we stand, notifying us that other positions may be more secure.

Escaping to the nearest bank, we find ourselves in the vicinity of a spot called Pierre à l'Échelle, to which we shall again refer. A little to the left of this descends a spur of Aiguille du Midi, which is known as Mont Mimont. On its flank, overlooking the glacier, is Pierre Pointue, one of the halting places in the ascent of Mont Blanc. This is the limit of the mule-path and about three or four hours from Chamonix.

The customary path from Pierre Pointue leads to the border of the glacier, in the vicinity of the great gulf, and thence along its margin to Pierre à l'Échelle. Here the traveler strikes diagonally across Glacier des Bossons to the Grands Mulets. Deflecting toward the right, he reaches the head of Glacier de Taconnay; then, looking up the mountain, scales the "Petites Montées," or Lesser Ice-Cliffs, and reaches the Little Plateau ("Petit Plateau"), which is succeeded by the Middle Plateau (Plateau du Milieu). From this, deflecting slightly to the left, he proceeds to climb the Grandes Montées, or Greater Ice-Cliffs, which brings him to the Grand Plateau. From here are three routes. The old one leads directly toward the dome of Mont Blanc; another turns to the right, toward Dome du Goûter, and thence, by the Dromedary's Hump, to the Summit. The third, and most frequented, turns to the left, and, leading up the terrible ascent of the "Grande Pente," brings him to the Corridor, thence past the Rochers Rouges, the Petits Mulets, the Mur de la Côte and the North Calotte to the summit.

The feelings which this scene inspires almost force our attention from the relative positions of localities. It is not alone as students of geography that we gaze upon the vast panorama of mountain and glacier which spreads before us like a map. If we have souls still blessed with the power of communion with the soul of Nature, they swell with the inspiration of the scene. It is not alone the ragged outline of the precipice or the grandly sinuous form of the stream of ice which occupies our attention, but even more than these, the spirit and meaning,—nay the divine revelation breathed by these gigantic forms, which absorbs chiefly the attention of the beholder. One inhales the spirit which moved Coleridge when he penned the "Hymn in the Vale of Chamonix."

"Ye ice-falls! ye that from the mountain's brow
Adown enormous ravines slope amain,
Torrents, methinks, that heard a mighty voice,

And stopped at once, amid their maddest plunge!
Motionless torrents! silent cataracts!
Who made you glorious as the gates of heaven
Beneath the keen full moon? Who bade the sun
Clothe you with rainbow? Who, with living flowers
Of loveliest blue, spread garlands at your feet?
God! Let the torrents like a shout of nations
Answer, and let the ice-plains echo, God!"

Starting from Chamonix, our path leads for half a mile through a grove of firs, without much change of level; then ascending in the usual zigzag fashion, we soon reach the beautiful little Cascade du Dard, which we contemplate from a pavilion or chalet which offers us refreshments and photographs of the scenes around us. A little distance beyond, we reach the torrent des Pelerins, which issues from a glacier of the same name, and has the interesting peculiarity of increasing and diminishing without regard to the weather,—sometimes descending with a devastating flood in the dryest periods. Here until 1853 existed a first-class cascade, when, in a time of flood, the blows of the descending blocks were so powerful as to batter down a cliff 200 feet high; and thus this natural curiosity, yielding the keeper of the rude inn a valuable revenue annually, was reduced to a fifth-rate affair. The chalet still stands, however, and the opportunity is still open to spend a few francs for refreshments.

The ascent next brings us to the brow of a ridge overlooking a ravine strewed with shingle, and noisy with the headlong rush of the Torrent des Praz, which gushes from the upper portion of the Glacier des Bossons. The voyager here looks down at least 500 feet into a gorge which, in times not geologically remote, must have been filled with a spur of the great glacier which still lives in the next valley.

We now rise above the limit of trees, and begin to enjoy a vast and magnificent landscape. Under the shadow of the last trees stand the chalets of Paraz. We are now two hours from Chamonix and more than 5,000 feet (5,264) elevated. Between here and Pierre Pointue the broad, unshaded acclivity is held in about equal parts by heaths and angular blocks precipitated, in the progress of ages, from the pinnacles of Midi, which tower almost directly above our heads.

Pierre Pointue is 6,700 (6,722) feet high,—a little higher than Mount Washington. Here stands a truly comfortable little inn, kept by one of the most intelligent and enterprising guides of Chamonix, Sylvain Couttet. Standing on the terrace of the inn, we look back upon the tree-tops long since past, and down into the quiet valley of Chamonix. On the opposite side rises the Brévent, from which we obtained our panoramic view of this situation. A little farther to the right is the Flégère; and behind and above both rise the red pinnacles of the range of the Aiguilles Rouges. Above us, and almost over our heads, shoot up the spires of the Aiguilles du Midi. Not far off to the south flows the rugged river of ice which we are soon to cross; while far up, over the fields of firn, rise the Aiguille and the Dome du Goûter. Mont Blanc is hid by Mont Mimont. We are already in the realm of the clouds, and their damp, pale forms ride past us like the spirits of the mountains.

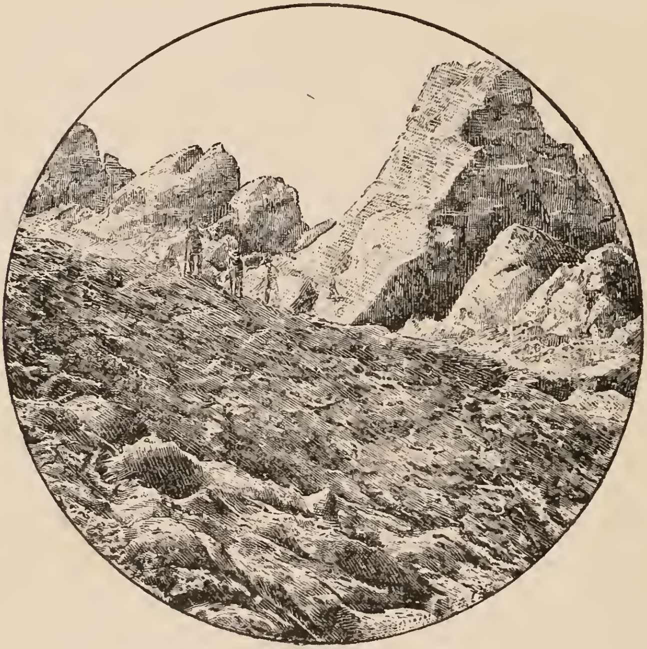
We press on around the steep slope of Mont Mimont, which dives down like a Gothic roof from the craggy crest projected against the blue sky, and almost crowds our path into a dark chasm awful to stand over. On the sunny slope of this mountain Alpine flowers flourish in equal beauty and abundance. I gathered here twenty-three species,—among them, the white gentian. In an hour we have reached the station called Pierre à l'Échelle. This is a block of granite twenty feet high, over which hangs the Aiguille du Midi. The guides call to the rocks on the opposite side of the glacier, and Aiguille de la Tour echoes back a distinct response. Vegetation continues beautifully developed. Rhododendrons, or Alpine roses, are plentiful.

A little beyond this spot we take leave of the solid land, to grapple with the difficulties of ice and snow. As in all cases, the boundary line of the glacier is a belt of disputed territory. Ice, rocks, gravel and earth promiscuously mixed, form an obstacle requiring strength and agility to pass it. Even at the outset, real dangers threaten us, for avalanches of ice and stones are almost perpetually precipitated from the heights of the crest running from the Aiguille du Midi to Mont Maudit.

These dangers and difficulties passed, it is customary to attach the whole party together by means of a common cord. Thus, an individual so unfortunate as to slip on a dangerous slope, or to drop into a concealed crevasse, will be held up by his companions. At the same time, the rope is liable to convert the accident of one into the disaster of the whole party. But the good chances outweigh the bad; and, as any individual may be the one to meet with an accident, all are willing to take the risk of being made the sharer of some other's misfortune,—a sort of life insurance on the mutual plan.

The mass of ice is cleft by crevasses running in every direction. Some of these we leap across with a vivid consciousness that our foothold, on either brink, is but the slippery ice. If too broad to leap, a light ladder is thrown across to serve as a bridge. Over this the timid crawl on hands and knees. The thought of being suspended by the rung of a ladder over a dark abyss without visible bottom is well calculated to arouse the nervousness of the most stolid. The snows of winter bridge many of the crevasses, and when these bridges are softened by the sun they become pitfalls, requiring the skill of experienced guides to detect them. The danger is greatly increased when the crevasses are concealed by freshly fallen snow.

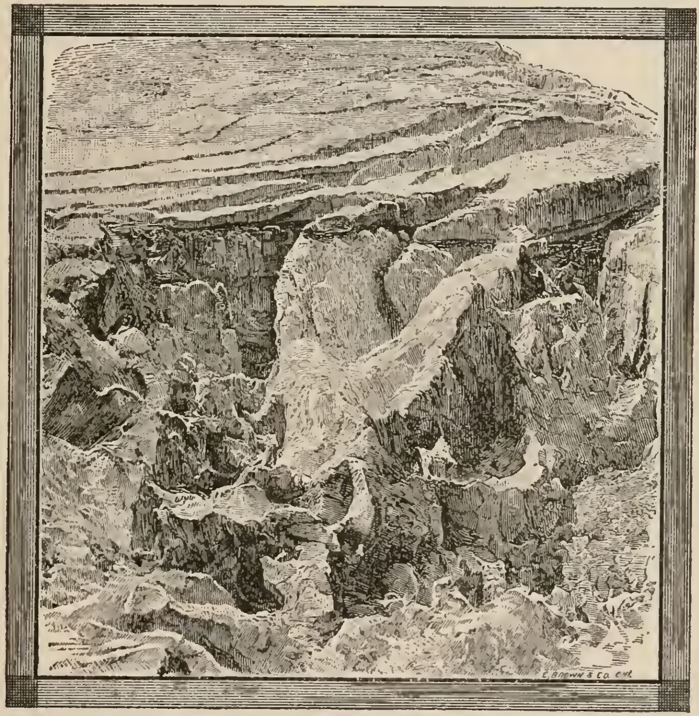
The intersection of the crevasses cuts the ice into vast prismoidal masses, standing vertically. The increasing separation of the walls of the chasms gives these blocks a sort of isolation. Very often, the lateral pressure, or some subglacial protuberance of rock, suffices to thrust such ice-masses into the air. These effects occur especially in the neighborhood of the junction of Glacier des Bossons with Glacier de Taconnay. This region is rather the parting of the broad field of ice by the protruding rocky ridge called Aiguille de la Tour. Striking against this, the ice-field is terribly wrenched. Outliers of this ridge crop out through the ice, from a quarter of a mile to two miles above, and other protuberances must exist, underlying the ice and heaving it up into the chaotic aspects which it presents. The very entrance upon this tremendous cataract of ice is through a sort of natural tunnel. Once in the region of the Junction, a fearful labyrinth lies before us. It seems at a glance impossible to cross. Here are some of the greatest difficulties encountered in the route to Mont Blanc. Pyramidal towers of ice are uplifted before us to the height of 20 to 50 feet. Séracs, rising in glittering columns, seem tottering from their base. Some, even, by the thawing action of the sun, rest on bases less in diameter than themselves,—ruined pillars of gigantic fairy palaces,—a very Persepolis of ice.



SÉRACS NEAR THE JUNCTION OF GLACIERS DES BOSSONS AND DE TACONNAY. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

All about us are effects on a scale of magnitude which almost staggers the understanding. It seems as if a sea had been solidified, then lifted up into the air and dashed upon the rocks.

These tremendous effects, however, have been achieved by the agency of forces at work before our eyes, and beneath our feet. Even while we stand here the Titanic forces are cracking and crunching the glaciers, and the deep thud which we hear makes us crawl with apprehension. Even before our eyes the great unfathomed stream of ice is marching on. While we stand gazing upon it the huge sérac rises or topples. At our very feet the dark crevasse opens its jaws wider and wider.



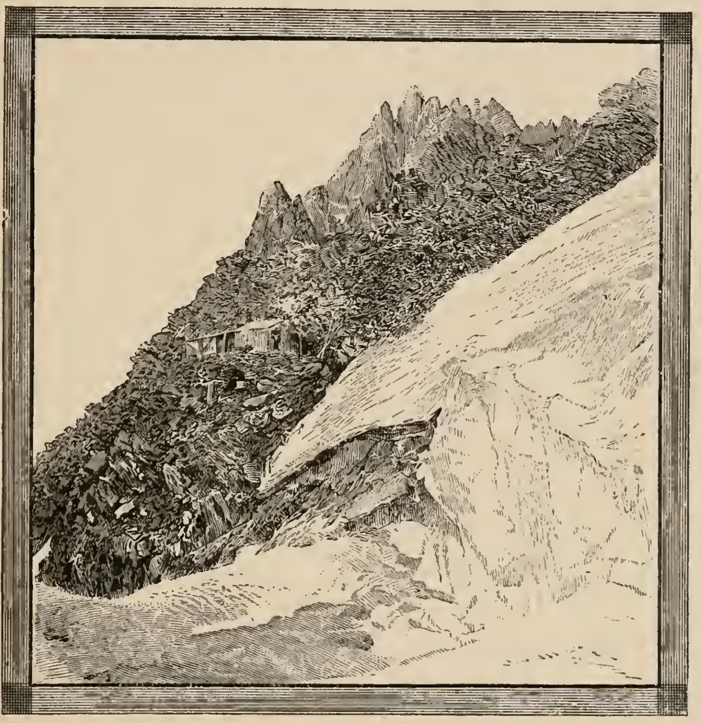
INCIPIENT CREVASSES AT JUNCTION AND THE PLATEAU. ASCENT OF MONT BLANC. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

But, like so many of the grandest operations of Nature, — like the uplift of mountains and the building of continents,— these operations are slow.— resistless though slow. The stream of ice moves but two feet in 24 hours.

The snow which falls on the summit of Mont Blanc requires 50 years to reach the foot of Glacier des Bossons. Like a stream of water, its velocity is slackened when its valley is widened, and accelerated when it narrows. When it reaches the brink of a steeper descent it breaks,—often with a report like the bass voice of the mountain calling to the sky. The fissure at first is but an inch or two, but it widens sometimes to a hundred feet, and acquires a depth of a thousand. If the declivity is steep, the glacier is parted at intervals of a few feet. A short distance above the chinks are narrow. Approaching the brink of the decline they grow wider. On the steep slope the whole stream, like water, is thrown into a state of wild confusion.

We escape from this labyrinth of ice by clambering up an almost vertical ascent called the Montée de la Côte. It is rifted in all directions by yawning crevasses, and the only practicable passage from block to block is by means of ladders. Sometimes we are suspended over a frightful chasm. Sometimes we are compelled to scale a vertical cliff of ice. Sometimes there is no alternative but to travel at the foot of an icy precipice over piles of snow and ice hurled down from the long slope above.

The rocks of the Grands Mulets now appear in sight,—the pinnacles of a mountain protruding 660 feet above the field of ice. Perched up on the side of the lower one can be seen the two cabins erected by the guides of Chamonix for the accommodation of voyageurs. The best view of these is from a position beyond and above. From this position the pointed architecture of the Aiguilles du Midi may be seen rising in the background. From a somewhat higher position we obtain an enchanting view of the valley of Chamonix and the cloud-wreathed mountains which rise on the other side. Chamonix and the other villages are distinctly seen, as well as the fields, the highways and the rivers Arve and Arveiron.



CABINS OF THE GRANDS MULETS WITH AIG. DU MIDI IN THE BACKGROUND (SEEN FROM ABOVE). ASCENT OF MONT BLANC. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

To the best of these two cabins we are only too eager to turn in search of rest for our wearied limbs. No charge for shelter, and for meals and rude lodgings no exorbitant demands. The best of these cabins is divided into two apartments, in one of which the ladies of a party enjoy a comfortable seclusion. We are now eight hours from Chamonix—eight working hours,—and 10,000 feet above the sea-level. The sun is sinking behind the needles of the Aiguilles Rouges, and our day's toil is ended. Here we must endeavor to gain such sleep as the place affords, and make an early start on the morrow. We retire as soon as the bars of slanting sunlight have been lifted from the head of Dome du Goûter, which rises under the calm sky above us. It is already dark in the valley.

Following the custom, we repose without removing any clothing. The night is chill, and three blankets are not refused.

It is always the case that when most anxious to sleep we sleep the least. Another party occupies the adjoining apartment, and, having no purpose to ascend farther. they feel no need of devoting the early hours to sleep, But we must turn out at two in the morning. Our neighbors' conversation is but partially deadened by the board partition, and, though carried on in low tones, is but too audible. We make most desperate efforts to sleep, but our heads are like beehives when the inmates swarm. Instead of sleeping, we perform triple work at thinking.

At length all is quiet, and the poppy has sweetly composed our eyelids.

Rap! rap!—it is the guide calling us to another day's work.

We set out at one or two o'clock in the morning, by the light of lanterns. Traveling mechanically, and half asleep, we traverse an expanse of ice which forms the upper limits of the Glacier de Taconnay, and encounter an almost vertical escarpment of ice, about 300 feet high. called the Petites Montées. Gazing in dumb amazement at this tremendous ice-wall, we notice that the clear but rugged ice below is surmounted by an entablature of stratified snow, giving us architrave, frieze and cornice, in due succession. We halt for the chief guide to cut steps; and then follow in a zigzag path to the Little Plateau, after a march of three hours. An hour later we reach the Middle Plateau. This is bounded by another glacier cascade called the Grandes Montées, shattered ice and yawning crevasses, and dusky caverns with icicles hanging from their snowy eaves. This slope escaladed, we are on the borders of the Grand Plateau. The giant domes of the mountains now rise above our horizon.

The Grand Plateau is a vast plain of snow, or rather, a broad, shallow firn-valley, about 13,000 feet above the sea-level. It is bounded by the dome of Mont Blanc, which lies directly in front of us, Dome du Goûter at our right, and Mont Maudit at our left. The old route pursued by Balmat and De Saussure lies directly across the Plateau; but the labors of the final ascent are terrible and the dangers imminent. Another route more frequented leads to our right, by the Dome du Goûter, and thence across the narrow crest connecting with the bosses of the Dromedary and Mont Blanc. This route is joined, at Dome du Goûter, by the path from St. Gervais. The third and most frequented route diverges to the left into the col or depression, separating Mont Blanc from Mont Maudit, and known as the Corridor.

We are now approaching what has been styled "the region of accidents." The Grand Plateau is detached by a series of Grand Crevasses from the mountain slopes which rise on the farther side of it. These crevasses are of such width and depth as to be absolutely impassable except in places where filled by avalanches of snow descending from above. The first catastrophe resulting from adventure upon Mont Blanc left three guides buried in the Grand Crevasse. It was in 1820 (August 19). Dr. Hamel, a Russian naturalist, accompanied by two Englishmen, Messrs. Durnford and Henderson, and eight guides, had imprudently forced his guides to proceed from the Grands Mulets on the morning of a day threatening stormy weather. They pursued the direct route, and had safely crossed the Grand Crevasse. They were climbing the last ascent. They were pursuing a zigzag course, in single file, about 600 feet above the Grand Crevasse. The freshly fallen snow was about 15 inches deep. Suddenly it began to slide down the steep descent. One of the guides had the presence of mind and muscular strength to force his baton in the old snow underneath the new and maintain his position, while the avalanche passed by. The others were thrown from their feet and borne along with accelerating velocity toward the pit which opened at the foot of the slope. Three of the guides were buried there, beneath 200 feet of snow which poured in upon them. The others escaped.

The unfortunate guides lost in the Grand Crevasse have furnished mournful testimony to the steady march of the glaciers. Forty-one years afterward (in 1861), on the lower part of the Glacier des Bossons, some dark objects were observed in the ice, gradually approaching nearer and nearer the surface. At length they were removed and found to consist of a portfolio, a piece of a pocket diary, a fragment of a bottle, the remains of a spiked alpenstock and a lantern. The entries in the diary remained perfectly legible, and testified to a certainty that these débris had belonged to the unfortunate guides of the Hamel expedition. Two years later some of the remains of the bodies of the victims came to the surface; and from time to time numerous other fragments have appeared and been identified by the clothing which accompanied them. Thus it appears that these bodies traveled from 26,000 to 29,000 feet in forty-one years, or about 680 feet a year. As they were buried 200 feet beneath the surface, it seems that 200 feet of ice had been melted from the surface of the glacier in the same interval.

A similar accident occurred in nearly the same spot in 1866 (October 13). Captain Arkwright, of the English army, was ascending Mont Blanc with three guides and a porter. His sister accompanied him to the Grands Mulets, and there awaited his return. His party was followed by Sylvain Couttet and a German gentleman, Winkart, whom he was guiding to the summit. The two caravans had crossed the Grand Plateau, and were scaling the terrible steeps leading up to the crown. Arkwright's chief guide was in advance, cutting steps in the ice. Couttet insisted on relieving him; and so Winkart and Couttet passed in advance. This change of positions had hardly been effected when a terrific crack was heard in the ice above. Couttet, comprehending the situation, cried out, "Save yourselves! To the right! To the right! Lie down!" He and Winkart instantly crouched beneath a precipice of ice, while a terrific avalanche of huge blocks of ice, crashing down the slope above, accompanied with clouds of snow and pulverized ice, leaped over them from the brink of the ice-cliff which sheltered them. Couttet and Winkart were safe, but the other four were hurried into an abyss from which no trace of them has ever been recovered.

What a message was left for Couttet to carry to Arkwright's sister! He returned to the Grands Mulets, but could not summon the courage to enter. He narrated the catastrophe to some brother guides, and implored them to break the sad news to the young lady, but they could not be persuaded. Finally he took courage and opened the door. She was seated at the farther side of the apartment by a window, with an album in her lap, making a sketch of the Dome du Goûter. Sylvain, seeing her so tranquil and unsuspecting, was overpowered by the sadness of the message which he came to deliver. He paused; he remained motionless, without the power to pronounce a word. She turned her head; she saw him and cried, "My brother, Sylvain!" "I was unable to speak," said Sylvain to M. Durier, who relates the incident. "My throat was choked; I could only throw up my arms. She turned as white as the snow; she arose; she went to the window; she kneeled; she uttered a prayer with her eyes toward heaven,— then came directly to me and inquired, 'How did it happen?' As soon as I could speak I said to her, 'We will look for him to-morrow.'" *

The Grand Crevasse has been the scene of an accident of a different kind. On the 9th of August, 1864, two Austrian Counts,— Schonkirchen and Wurmbrand,— had safely effected the ascent, and were returning in the afternoon, by the same route, across the Grand Plateau. They had crossed the Grand Crevasse in the morning by a snow-bridge, which, though appearing less secure than desirable, carried them safely over. They reached it on the return at one or two o'clock in the afternoon. The day was mild, and the sun had softened the snow to an

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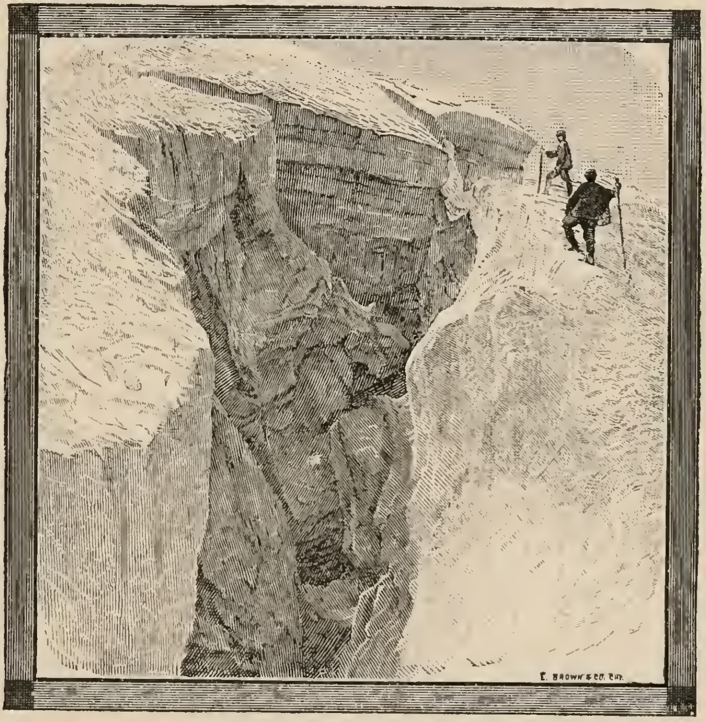
* Durier, *Histoire du Mont Blanc*, pp. 84, 85.

unusual extent. The leading guide was proceeding cautiously over this bridge. He had reached the middle of it, when, to the consternation of his companions, he dropped suddenly out of their sight. The bridge had yielded, and he had disappeared in the icy abyss. They tied together the ropes which they carried with them, and let the line down into the crevasse, but no hand seized it. No voice, no moan arose from the darkness which concealed the bottom. The next day a rescuing party, brought from Chamonix, lowered one of their number 160 feet into the crevasse, but without the discovery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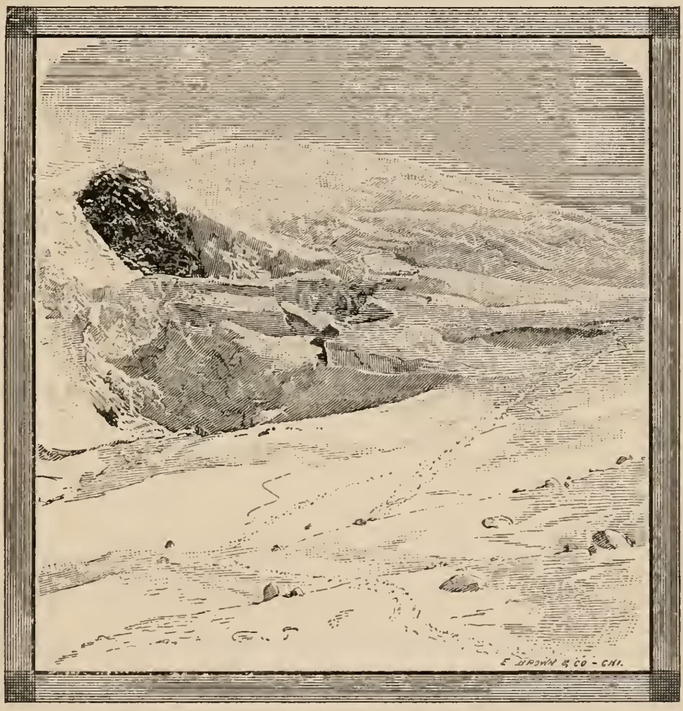
GRAND CREVASSE AT THE FARTHER BORDER OF THE GRAND PLATEAU. ASCENT OF MONT BLANC. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

of the victim or the bottom. Hair and blood were seen on the walls of the chasm, but the remains will only be recovered at the end of a funeral march of forty years.

These accidents all transpired on the direct route. Let us turn to the left, and make an ascent by the Corridor. We cross the Grand Crevasse and scale the fearful slope which borders the Grand Plateau on three sides. We are in the Corridor. We have gained an elevation from which we look over the Alps — into the land of Italy. A stiff breeze is drawn through this depression, which penetrates to the moistened skin. Such a breeze, in this very spot, was the occasion of the first lady victim in the history of ascensions. It was on the 2d of August, 1870. Mrs. Mark and Miss Wilkinson were on the way to the summit in company with Mr. Mark and a couple of guides. Arriving in the Corridor, the strength of the ladies gave way, and they resolved to remain with one guide while Mr. Mark and the other proceeded to the summit. But the frigid wind induced the ladies to seek a position a little lower and more sheltered. Mrs. Mark was nearly exhausted and leaned upon the arm of the guide. Suddenly both sank through the snow into a concealed crevasse, of which no sign presented itself at the surface. Miss Wilkinson's shrieks brought back Mr. Mark and his guide. Nothing could be heard, and nothing seen, except the hole in the snow perforated by the united weight of two persons. The guide's politeness had cost them both their lives. The next day Sylvain Couttet was let down by a rope to the depth of 65 feet. Here the walls of the crevasse were so much approximated that he was unable to descend farther. By means of his staff he ascertained that the fissure enlarged six feet below this strait, and he could feel there the pile of snow which descended with the victims, and beneath which they lay entombed. The momentum of their fall had crushed them through the narrows of the crevasse, and their blood had been left upon its walls to record the terrible tale.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SUMMIT OF MONT BLANC AS SEEN FROM THE GRAND PLATEAU. ASCENT OF MONT BLANC. FROM A PHOTOGRAPH BY J. LÉVY ET CIE., PARIS.

Turning to the right from the Corridor, we ascend, by steps cut in the hard snow, the steep which leads to the summit of the Rochers Rouges. The last rocks seen are the Petits Mulets. Thence we ascend another acclivity called the Mur de la Côte. This has been also the scene of a dreadful catastrophe. On the 5th of September, 1870, a successful trip to the summit had been effected by two American gentlemen, Mr. Randall, of Newburyport, and Dr. Bean, of Baltimore, accompanied by Mr. Corkindale, of Scotland, and eight guides,— in all eleven persons. Not one of these ever returned. They were seen from Chamonix to have begun the descent. In a few minutes they were concealed from view by thick clouds, which were followed by a violent tempest of snow. At evening they had not returned. Two days after an effort was made by a rescuing party to reach the summit, but the unchained tempest compelled them to return. It was not till the 17th of September that relief could reach the spot where the party had been seen enwrapped in the whirlwind of snow. Relief, of course, was unavailing. At the summit of the Mur de la Côte were found the bodies of Corkindale and two of the guides; a little above were the bodies of Dr. Bean and another guide. These corpses were completely congealed. The six remaining victims could not be found. Some notes in a pocket diary of Dr. Bean impart all the further knowledge in our possession respecting the last anguish of these unfortunates.

"*Tuesday, September 6.* I have made the ascent of Mont Blanc with ten persons,— eight guides and Mr. Corkindale and Mr. Randall. We reached the summit at half-past two o'clock. Immediately after having quitted it we were enveloped in clouds of snow. We have passed the night in a grotto dug in the snow, which affords us only a very imperfect shelter, and I have been sick all night.

September 7, morning. Cold excessive; much snow, which falls without cessation. The guides are very uneasy.

September 7, evening. My dear Hessie, we have been two days upon Mont Blanc, in the midst of a terrible tempest of snow. We have lost our way [they were only a few steps from the usual line of descent], and we are in a hole dug in the snow, at a height of 15,000 feet. I have no hope of descending. Perhaps this notebook will be found and sent to you. We have nothing to eat. My feet are already frozen, and I am exhausted. I have only the power to write a few words. [All this was written in characters larger and larger, and almost illegible]. Tell C. that I have left the means for her education. I know that you will employ them properly. I die in the faith of God, and in thoughts of love for you. Adieu to all. I hope we shall meet again in heaven. Yours forever."

A catastrophe still different from any which I have related transpired in nearly the same situation upon the North Calotte of the mountain dome. Three young Scottish noblemen, brothers, by the name of Young, resolved, against all remonstrances, to ascend Mont Blanc without the assistance of guides. Following the tracks of a preceding caravan, they made the ascent with complete success, on the 23d of August, 1866. The weather was fine, and they were watched with telescopes from Chamonix. On commencing their descent, it was observed that they were pursuing a course a little too far to the north. The slope was very steep and very smooth. The hindermost brother was seen to slip and commence a glissade. His connection with the two others by means of a cord was the cause of their fall. Within a few seconds the three brothers had slid 800 feet to the brink of a vertical precipice of ice. Over this they shot, and landed 50 feet below upon a pile of snow and ice, which carried them 150 feet farther. All seemed dead for some instants, but the oldest was only stunned; the second brother was both stunned and oppressed by the stupor often experienced in ascending high mountains; the youngest, however, was lifeless.

All this was seen from Chamonix. In ten minutes a caravan of eight persons was on its way to the rescue. The next day news came from the Grands Mulets confirming all that had been apprehended. The two surviving brothers had arrived there at nine o'clock in the evening,— the younger blind. A storm coming on, another caravan set out to rescue the first, and, at a later hour, still a third. The first rescuers had become enveloped in a blinding storm, and could not pick their way. They had reached the region of imminent dangers, and dared not advance. One of the following caravans found them on the brink of that terrific precipice, 500 feet high, which stretches from the Mont Maudit to the Rochers Rouges,— known to the guides as the Grand Pente. All arrived safely at Chamonix after the storm, bearing the body of the unfortunate youth, whose neck had been broken in the terrible glissade.*

From these narratives it appears that the great dangers of the ascent lie between the Grand Plateau and the summit, and that they consist of five classes: 1. Protracted snow-storms accompanied by severe cold. 2. The

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*For the particulars of this and other catastrophes occurring previous to 1869 I am indebted to the admirable *Guide Itinéraire du Mont Blanc*, by Venance Payot, naturalist, at Chamonix. For particulars of later accidents I have consulted Durier's *Histoire du Mont Blanc*.

disengagement of avalanches of freshly fallen snow. 3. The precipitation of avalanches of snow and ice. 4. The loss of foothold and a fatal glissade. 5. The treachery of snow-bridges over crevasses.

This catalogue is too long to be very comforting, but I think it may be safely asserted that the Chamonix guides, if well selected, and allowed to exercise their own judgment, will not lead the voyager into any very extraordinary dangers. They are generally an intelligent, truthful and honest class of men. Their services are regulated by a system of public ordinances, and only guides of knowledge and experience are permitted to conduct parties to the summit of Mont Blanc.

We complete now our last ascent, and enjoy the fruits of the labors and dangers of the past two days. I do not like to affirm an exact equation between the fruits and the labors. It is true that we can turn about and look down on the clouds which hover over Chamonix, and toss our heads in disdain over the summit of the terrible Mont Maudit. It is true that we can turn upon the heel and see below us the summits of the Aiguille du Géant and the Grandes Jorasses, and look down in the dish-shaped ice-field which forms the great Glacier de Talèfre, with the Jardin blooming in its midst. It is true that we can discern in the dim distance the conical form of the grim and solitary Matterhorn, and the frosted heads which look up to it from the neighborhood. It is true that we can turn still farther on our heel and see the fleecy backs of clouds which float over the glacier of Ruitors and the valley of Aosta, on the Italian side of the Great St. Bernard. But in all truth and candor it must be admitted that the realization is not commensurate with the anticipation. Even a less impulsive and less sentimental traveler than De Saussure would feel moved to stamp his foot in a sort of impatient disappointment.

But the situation, though less abounding in spectacular interest than we may have anticipated, is plentiful in suggestions and reminiscences. This spot has been the goal of a great deal of ambition. Besides the idle and fruitless ambition of the mere curiosity-hunter, science, in the person of De Saussure, labored a quarter of a century to accomplish what is now accomplished by not less than 50 tourists and 100 guides annually. De Saussure made a sojourn of two weeks on the rocks of the Col du Géant for the purpose of scientific observation. MM. Charles Martins, Bravais and Lépileur, more daring, planted their tent upon the snow-fields of the Grand Plateau, at an elevation of 13,000 feet, and there passed several days. They improvised a floor of fir boards laid upon the snow. One may form an idea of what devotion to science means when informed that in that situation the rarefaction of the atmosphere is such that charcoal ceases to burn the moment one ceases to blow it, and that consequently these men, assailed by a terrific snowstorm, had only the flame of a spirit-lamp to keep them company during the night. Their example was followed by Dr. Pitschner, in 1859 and in 1861; but he placed his tent at the Grands Mulets 3,000 feet lower. In 1859 Tyndall and Frankland, also, spent twenty hours upon the summit, including one entire night. They slept with six porters and three guides under a light tent upon the snow, the temperature of which was but five degrees above zero. Tyndall tells us that though the north wind blew fiercely, they suffered nothing from cold during the night. They had with them six candles, which they burned one hour. These on returning to Chamonix, they weighed, and, after burning there another hour, weighed again. The loss of weight in each instance was the same. This was a surprise, since the light of the candles was much feebler on the mountain than in the valley. The sound of a pistol was found to be short, like the pop of a champagne cork. On this occasion, posts were planted in the snow at several stations, one of which was the summit. To these, registering thermometers were attached, for the purpose of marking the extremes of temperature during the year. Others were planted in the snow. In 1860 Professor Tyndall made efforts to ascend to the summit to examine his thermometers, but was repelled by the "execrable weather." In 1861 he succeeded. The post remained on the summit, but the thermometers were broken.* He states, however, that a thermometer left at the summit of the Jardin during the winter of 1858 recorded a minimum temperature of eight degrees below zero.

Life is not wholly extinct in these glacial solitudes. On the most elevated rocks, but a few hundred feet beneath the summit, are found certain species of mosses and lichens, and even microscopic animals. There is also an insect which makes its home upon the glaciers, and hides in the crevices and pores which permeate their mass.

I must not leave Mont Blanc without giving briefly the story of Balmat. De Saussure had awakened among the cantoniers of Chamonix a lively interest in the discovery of a route to Mont Blanc. He had offered a reward to the first who should succeed. Jacques Balmat entered into a lively sympathy with the aspirations of the Genevese scientist. "The project," says he, as reported by Alexander Dumas, "was always in my head,—by night as well as by day. By day I ascended the Brévent and spent hours in searching for a route. By night I could scarcely close my eyes before I dreamed that I was on the way." One day he told his wife he was going to search for crystals. He took a baton doubly ironed, and longer and stronger than usual, put a bit of bread in his pocket, and set out. He had tried the route by the Mer de Glace, but the terrible Mont Maudit barred the passage. He had gone by the Aiguille de Goûter, but the crest which connects it with the Dome du Goûter was found only one or two feet wide, and the precipices on either hand were 1,800 feet deep. "Merci!" He determined, therefore, to pursue, this time, another course. He went by the Glacier des Bossons as far as the Grands Mulets. Night overtook him, and he wrapped himself in his blanket and sought repose upon the rocks. "Toward nine o'clock," says he, "I saw approaching the shadow which mounted the valley like a thick fog, and advanced slowly toward me. At half-past nine it reached me. Meanwhile I saw above me the last rays of the setting sun. They disappeared, and the day was gone. Turned, as I was, toward Chamonix, on my left was the immense plain of snow which mounted to the Dome du Goûter; on my right, within reach of my hand, a precipice of 800 feet descent. I was unwilling to sleep, through fear of rolling off my bed while dreaming. I seated myself on my sack and commenced beating hands and feet to restore warmth.

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* Tyndall, *Hours of Exercise in the Alps*, p 58.

"Soon the moon rose pale in a circle of clouds. At eleven o'clock I saw, descending from the Aiguille du Goûter, a rascally fog * * * Every minute I heard the fall of avalanches rumbling like the sound of thunder. The glaciers cracked, and at each crack (craquement) I felt the mountain move. I was neither hungry nor thirsty, and I experienced a singular pain in the head, which began at the top of the cranium and descended to the eye-brows. The fog was still floating around me. My breath froze upon the handkerchief which I had tied about my face. The snow wet my clothes; it seemed to me that I was naked. I redoubled the rapidity of my movements and set myself to singing, to chase away the horrid thoughts which came into my mind. My voice lost itself in the snow; no echo made response to me."

Thus he passed the uneasy night. Day dawned at two o'clock. Sunrise brought premonitions of storm. Balmat must not attempt Mont Blanc. He spent the day in exploring the glacier, and slept the next night upon the solid land. On the third day he descended to the first village, and met some fellow cantoniers, who persuaded him to join in an expedition in search of a path to the summit. He was entirely reticent about his own undertakings. He went home and put on a change of clothing, replenished his sack, and at eleven o'clock at night joined his companions on a journey to the unapproachable dome. They reached the Dome du Goûter. It was the fourth day of Balmat's efforts. He started in advance to cross the crest which connects with Mont Blanc. It was so narrow that he mounted it astride. Success seemed about to crown his gigantic endeavors, but alas! the crest itself was cut by crevasses, and he was obliged to retreat.

His companions had abandoned him in despair. He took his sack and descended to the Grand Plateau. He was piqued at the treatment of his comrades. He resolved on desperate adventures. He climbed the terrible slope to the Corridor and passed over to the Glacier de Brenva. He looked down on Courmayer and the valley of Aosta in Piedmont. He looked toward Mont Blanc and thought he saw a way to ascend, but would not, because his companions would not be witnesses. It was night, and he stood in a wilderness of snows and frosts and storms. He descended; he encountered the Grand Crevasse. Darkness enveloped him, and he found no way to cross. Nothing but the dire and untried alternative of a night upon the ice was before him. Alpine snow shot through the air like needles. It was a fearful fate, but Balmat's heart never felt fear,— nor despondency. We must imagine how the night was passed. He looked down on the lights of Chamonix and thought of his companions in their warm beds. He wondered if they would think of him. The "craquement" of the glaciers sounded from minute to minute. In the intervals of silence he heard the barking of a dog at Courmayer. "That," he said, "diverted me; it was the only sound from the earth which reached me. Toward midnight the evil cur was silent, and I fell again into that devil of stillness which one experiences in cemeteries; for I took no account of the noise of the glaciers and avalanches which startled me. At two o'clock I saw appear in the horizon the same line of light as on the two previous nights. The sun followed as before. Mont Blanc also donned his perruque; he does this when in bad humor, and then there's no use meddling with him. I was acquainted with his character, and I determined to leave him undisturbed. 'When he smokes his pipe,' as they say in the valley, 'there's no use trying to extinguish it.'"

It was the fifth day with Balmat on the mountains. He had noticed the steep ascent to the summit of the Rochers Rouges. He ascended it; he looked toward the dome of Mont Blanc,—*and had discovered the long-sought way of approach.* He returned to Chamonix and slept forty-eight hours.

It was two weeks, however, before the weather favored the final undertaking. He had confided his secret to Dr. Paccard, who had consented to accompany him in the next ascent. They left Chamonix by stealth. None but three women knew of their plans. They were to watch for the adventurers on the dome at a certain hour on the following day. They slept the first night on the borders of the Glacier des Bossons. The next day Dr. Paccard was overcome by the fatigue and somnolence which accompany mountain climbing. He reached the Corridor, and a gust of wind blew his hat over the crest toward Piedmont. At the foot of the Calotte, or cap of Mont Blanc, he refused to advance. Balmat pushed forward alone,—iron-hearted,—iron-framed. The pelting snow caused him to keep his head bowed down for protection of his face. He noticed a change in the nature of the surface. "I raised my head," he says, "and perceived that I had conquered at last the summit of Mont Blanc. Then I turned my eyes around me, trembling lest I were deceived and should discover some new pinnacle, for I felt that I had not the strength to climb it. The joints of my limbs seemed to hold together only by the aid of my pantaloons. But no; I was at the end of so many explorative and fruitless marches. I had arrived where no person had yet been,—not even the eagle or the chamois—alone,—without other reliance than that of my strength and my will. All which surrounded me seemed to be mine."

He turned toward Chamonix and waved his hat in the air. All the village had assembled to witness a human being on the summit of that white and eternally solitary dome. *All the village!* They had confided their secret only to three women!

We leave Balmat to get himself and his half-dead doctor back to Chamonix as best he may. The doctor was blind, and Balmat was equally so on the following day. At the end of four days he went to Geneva to notify De Saussure of his success; but he tells us curtly, "The English had got the start of me." Brave Balmat!—"Balmat of Mont Blanc," as the King of Sardinia titled him. He sleeps at length in a crevasse. Fifty years afterward, at the age of 72, he fell from a shelf of rock into the depths of a fissure, from which his body was never recovered,—a grandiose and fitting sepulcher for the first invader of the drear solitudes of Alpine snows and ice. "The ancients would have imagined that this conqueror of the mountains had disappeared in an apotheosis."

Balmat's success was in 1786. De Saussure was unable to effect his long-desired ascent till 1787. Six days later he was followed by an Englishman, Col. Bagley. The only ascent in 1788 was by another Englishman, Mr. Woldley. No more ascensions occurred till 1802. From that year to 1853 there were, in all, but 63 ascensions. In 1860 there was but one reported, though in 1861 there were 39.

In 1869 we have a record of 54; in 1870,—the year of the Franco-German war,—14. The maximum number has been 58, in 1873. In 1874 there were 41.

The nationalities of the ascensionists are noteworthy. From 1819 to 1834 they were all English, except two Americans. From 1847 to 1858, inclusive, all were English and Americans, except eight. The total number of English ascensionists has been 457; of Americans, 82. The French have had 75 representatives; Savoy and Switzerland, 42. The total number of ascensions has been 775. Of every nine ascensionists, five have been English and one American. English-speaking people have constituted two-thirds of the whole. The total number of lady ascensionists has been 30; of whom 4 ascended in 1874. One was a Spanish lady, who only succeeded on the third attempt. Chamonix gave her an ovation for her bravery. The first lady ascensionist was Mademoiselle Paradis, of Chamonix, in 1809; the second, Mademoiselle H. d'Angeville, of France, in 1838. The third was an English lady, Mrs. T. Hamilton. The first American lady to make the ascent was Miss Brevoort, of New York, in 1865. The first Americans were Howard and Rensselaer, in 1819. There have been six fatal accidents attending ascensions from Chamonix. Six tourists have been lost, including one lady,—only one in 129 persons. No accidents have occurred on the Chamonix side since 1870. In 1874, however, there occurred a catastrophe on the Courmayer side, in an attempt to ascend by the Glacier de Miage. Night overtook the party while in the upper region of the glacier. They were compelled to keep in motion to avoid being frozen. They proceeded with caution, cutting steps in the ice; but the voyageur missed his footing, slipped, and drew with him his two guides into a profound crevasse. One guide only escaped, and the unfortunate tourist now rests in peace in the cemetery at Courmayer.*

These narratives and statistics illustrate a grand fact in the experience of mankind. It is further illustrated in the connection of mountains with epochal events in the world's history. Ararat, Sinai, Horeb, Calvary, Atlas, Ida, Pindus, Olympus, Parnassus; these are names with which the profoundest history of our race is inseparably connected. There is more in mountains than the novelty of the outlook from their summits. They stir the higher susceptibilities of the intellect by their magnitude, their loftiness, their grandeur, the unapproachableness of their summits,—their symbolism of power and eternity. No man can contemplate the aspects presented by a nobly uplifted mountain pinnacle or dome without feeling that his thought is expanded, unchained and newly-gifted; and that a new birth has been given to the sentiment of the sublime within him. There is more than this in the influence of mountains. They elicit and exercise the *morale* of the soul. "High mountains are a feeling." The dweller among mountains has always been free—he must be free. He in whose soul have been knit the impressions of wide extended landscapes and noble mountains is himself a scion of nobility. Mountains fire the soul with a spirit of veneration. They are the symbols of infinite power; they command our worship; whether we reason or not, they force us to bow the spirit in their presence. They are the homes of frost, and silence, and mystery,—the brows which bear the wreath of the clouds, —the eyries of the lightning and the thunder,—the palaces of infinite power and majesty. They restrain us from their presence like august monarchs. They reach up to heaven and reflect a celestial radiance down to us, while we, in our weakness, must remain below.

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* These facts, with others in reference to 1874, have been kindly communicated to me by M. Payot, of Chamonix, since my return to America.

> "Not vainly did the early Persian make
> His altar the high places, and the peak
> Of earth-o'ergazing mountains, and thus take
> A fit and unwalled temple, there to seek
> The spirit in whose honor shrines are weak,
> Upreared by human hands. Come and compare
> Columns and idol-dwellings, Goth or Greek,
> With Nature's realms of worship. earth and air;
> Nor fix on fond abodes to circumscribe thy prayer."

THE BEAUTIFUL.*

WHATSOEVER is true is beautiful; whatsoever is good is beautiful; whatsoever is beautiful is *both true and good.* The world is delightful because it is beautiful,— not because it yields us food and raiment, warmth and ease. Science and philosophy delight us, not because they afford us knowledge, but because the true in the world external to the soul attunes so beautiful a harmony with the soul itself. The truths of science and philosophy we apprehend and utilize; it is the beauty and sublimity of the truth which we enjoy. The sight of spotless virtue, or of a great and noble deed, sends through the heart a thrill of pleasure; but not because some benefit comes to the world; it is because there is something in the human soul which stirs in sweet response to a thing which is sweetly and grandly good.

How large a volume of pure enjoyment is conferred upon man in the existence of the beautiful! The beautiful seems created for no other purpose than the enhancement of the happiness of sentient beings. Blot out of existence all which appeals simply to the æsthetic sense, and we should still live, and eat, and think, and worship,— but how would the rewards of thought and worship shrink in our esteem! Erase from the soul the power to discern the beautiful, and the result would be the same.

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* A commencement address before the State Female College, Memphis, Tenn.

The sky,—blue, serene, immaculate,—would no longer awaken an emotion. The distant star would send its ancient light to eyes leaden as those of the hound upon the porch. The exquisite colorings of violet and rose; the universal bloom of spring; the fire in the sunset cloud; the spirit hum of the breezy forest; the many-voiced chorus of morning birds; the dark green depths of the ocean, brooding over the wrecked argosies of a human race,—these all would be mere plain facts to apprehend, not inspirations on which to soar. The cloud might water the scorching crop without diffusing a radiance of supernal light from its brow, or hanging the love-tinted bow upon its bosom. The hill-side stream might convey its comfort to the thirsty beast without making all the air vocal with a music which causes the human heart to leap for joy. Man would be able to subsist without pansies, and mocking-birds, and rainbows, and stars. If every object were brown and square to the visual sense, if every taste were bitter as aloes, and every sound the grating of a file, and every fragrance the fetor of putrescence, man would still be able to live; family relations might subsist; science might not become extinct, and religion might linger as a sapless tree in a rainless clime.

But such a world is not ours. Such a world does not exist. God loves beauty, and because he loves it he has made everything beautiful, and because we are like God we love the beautiful, and participate in the happiness of God.

The beauty which fills the world is as abundant and as free as the sunlight,—nay, sunlight and starlight in all their infinite wanderings are the very vehicles of beauty to every world and to every intelligence. There is no monopoly of the world's beauty,— no preëmption,— no petty sovereignty to curtail the absolute rights of every intelligence to enjoy it. You cannot destroy it, you cannot conceal it. Even destruction and death put on hues of beauty, and stir our souls with exquisite emotions. There is none so poor that he is not a proprietor of the world's beauty; none so unlearned that he does not understand and discern and enjoy the beautiful. The beauty which blesses life does not depart when sunlight retires behind the mountain, and leaves the voiceless stars glinting down, like Raphael's cherubs from the casements of heaven; nor when the blazing sun arouses us to the labors and cares of real life, with the sights and sounds of the landscape to cheer us, or the tender evidences of some beautiful love to kindle a heaven in our hearts. Not when our eyes are closed, — even with the seal of blindness,— can we be robbed of all the beauty of the world, for love, which so often enters through the eyes, will find some other avenue to our souls; and the mind's eye will not be blind, but will contemplate the serene beauty of truth; and the eye of religious faith will even grow clearer, and the strings of the soul will become more perfectly attuned to the influences of heaven, and the whole nature will be pervaded by a harmony which is both music and light. Nay, when we pass from the light of the heaven of stars, do we not enter the light of the serener heaven of blessed spirits?

The world has been made beautiful to make man happy, and art is the translation of the world's beauty to man's intelligence. The soul, with its wonderful play of faculties and its consummate system of interactions with the material world, has been made beautiful, to attract us to the study of it and affiliate us to our heavenly Father. Virtue has been made beautiful because we possess a capacity of admiring and seeking virtue, and we have been gifted with this capacity to stimulate us to the encouragement and the practice of virtue. The genial light of love irradiates our households, not to lure us to the service of the individual or the race, but to make such service tributary to our happiness.

Shall we not attempt to secure some glimpse of the nature of beauty,—the sources of beauty, and the faculties by which we apprehend the beautiful? Far from us be the phrases of metaphysics and the subtleties of the schools. I think the nature of æsthetic perception is exposed to common sense. There are ideas of *reason*,—thoughts, ideals, models of the beautiful uncreated,—ideas of order, harmony, fitness, symmetry, unity of plan. We cannot define them or describe them. The more we attempt to bring them forward into consciousness, the more fugitive they seem; but we know such ideas, principles, rules or standards are there,—in reason. Then the forms or relations of things, or attributes of characters or lives, come to our knowledge,—this is an exercise of the *understanding*. Next, *judgment* compares these cognitions of the understanding with the imperishable ideals in the reason, and pronounces an agreement or disagreement of the objects with those standards or criteria of the beautiful. Lastly, if the judgment affirms a conformity of the object with the standard of beauty, a peculiar *sensibility* is awakened, which gives us pleasure; if it is a disagreement affirmed, the sensibility is painful. *This sensibility is the æsthetic feeling*, and this is the only thing in the complete process of æsthetic perception which is peculiar.

The beautiful thing is cognized in the same way as a mathematical figure is cognized. It is compared with a primary datum of reason by the same faculty as makes comparisons in other cases, and the rational element is simply one of the body of regulative principles which tacitly, and with most persons, unconsciously, control all thinking. The *feeling* only is peculiar. This, however, is immutably distinct from every other power of the soul, and proclaims a purpose of the Creator to correlate man with the beautiful with which he has garnished the world of forms, the world of thoughts, and the world of feelings.

Let this suffice for a search after the faculty by which we seize hold of these glorious gifts of God. Let us see if we can ascertain *what the beautiful* is. If we are unable to define it, we may certainly discover where it resides, and how varied are the circumstances under which the beautiful unveils its face.

High authorities have ranged the appropriate themes of philosophical research under the three categories of "The True, the Beautiful and the Good." These, it is thought, cover the whole ground. There is reason in such an analysis; but I, who am not a philosopher, shall venture to deny that anything can exist which is beautiful only. The very conception of the beautiful is inseparably coupled with the conception of the good. You feel it absurd to affirm the possibility of a beautiful thing which does not confer a happiness.

> "A thing of beauty is a joy forever."

So of the true. Contemplate it as a thought to which some reality corresponds. Here is a harmony between the ideal and the actual which, like all harmony, awakens an emotion of pleasure. It is beautiful. *The true is beautiful.*

Think of the spotlessness of infancy. It is a character perfectly coördinated with our idea of innocence. We apprehend the beauty of the moral harmony and experience delight. *The good is beautiful.*

Think of anything beautiful,—a beautiful statue. Being beautiful, it conforms to the standard of beauty existing in the reason; it is therefore true. *The beautiful is true.* In being beautiful it awakens delightful emotions and confers happiness. It is so far *good.* But that true beauty which inculcates by example, fidelity to a divine idea established in reason, is a moral influence. *The beautiful is morally good.*

It is impossible, then, to contemplate the beautiful abstracted from the true and the good. Everything ordained to exist discloses the beautiful in ever-varying guise. We must range through the universe and note where this spirit from heaven has made her dwelling-places.

First, there is PHYSICAL BEAUTY,—the beautiful in visible things. *Nature* is beautiful. In every realm and in every element, the æsthetic sense is feasted on a luxuriance of forms, and colors, and relations, in which beauty is superadded to provisions which seem to occupy the primary place. We find nothing which is useful alone; ornament, grace, coloring, finish, are lavished everywhere. The variety in nature's beauty is not less striking than its universality. It amazes us with its vastness; it confounds us with its minuteness. It is the beauty of supernal and infinitely blended colors; the serene majesty of uplifted mountains, carrying thought to the very heaven with their pinnacled summits, and to the very heart of the earth with their deep-rooted bases. Nature's beauty is as exquisite as it is universal and varied. The completeness of nature's attempts at beauty is consummate. Here are no signs of limitation of skill, or taste, or power. Scan the finest work of a human artisan, and beyond a certain limit you detect its imperfections. You gauge and measure the possibilities of his skill. But subject the workmanship of nature to a similar scrutiny, and you discern an astonishing contrast in the perfection of details. Every minutest line and feature is as exquisitely executed as the principal ones. Apply the microscope, and penetrate deeply the infinitesimal parts; to the utmost limit of your scrutiny, the same perfection of finish continues; and when you desist from the search for a measure of nature's skill, you leave your task convinced that the same careful and beautiful workmanship continues on and on, down through the ranks of the infinitesimals, beyond the power even of reason or imagination to penetrate.

Lift up your eyes on one of nature's landscapes. We transport ourselves in thought to Switzerland,—the land of lakes and glaciers and needled mountain heights.* We seat ourselves upon a shaven lawn. Behind us, in retreating order, are flower-plots, and trained shrubbery, and proudly ancient oaks; and from the midst of the verdure rises dazzlingly the balconied and majestic château of a Rothschild,—a banker king. In front of us is a panorama such as no eye can rest upon without a regeneration of heart. The grassy turf descends till it loses itself in the dark forest, on whose tufted summits we look,—*over* whose summits we look,—to the lake of Geneva, with waters as blue as the sky which bends over it, and as serene. Far along, to right and left, this obverse of the summer sky sends up its celestial sheen, and we seem almost to place our feet upon the floor of heaven. Beyond is the shining, grass-bordered shore, in the rear of which the rounded forms of a young forest uprise in expanding succession, till the plain is all a-bubble with emerald swells. Toward the left, the dark, straight back of the neighboring Voirons rises up to bound the plain, and project a line along the soft expanse of the sky.* Toward the right the plain is strewed with the fields and villas and suburban seats which skirt the charming city that crouches behind the forest screen erected this side of the lake; while beyond the suburban landscape rise the Great and Little Salève, whose parallel courses of mountain masonry may be satisfactorily studied by the young geologist from the window of his school-room in the city. But directly in front are the chief objects of the picture. The Voirons and the Salève approach each other in the distance. Through the interval which separates them the green and dusky mountain-tops emerge in succession into the upper air, and the massive Môle lifts its pyramidal form highest of all from their midst. Beyond the dark-swelling mountain-tops — beyond the Môle — rises the stupendous form of Mont Blanc,— his snow-wreathed crown and glacier-mantled shoulders radiant as the glory of heaven in the afternoon sunlight. * * * From grassy bank and mirror lake to rock-ribbed hills and Alpine domes glistening in the splendor of eternal snows, what an array of beauty is here! What a range of beauty is here! And to this array of natural beauty is added the associated interest which clusters all about this paradisiacal valley and lake. Near this spot, at Ferney, is the picturesque old villa of Voltaire. At the left extremity of the lake is the mediæval castle of Chillon, redolent of historic lore, and preserving still the footmarks of the chained prisoner, Bonnivard, worn in his dungeon's stony floor. At the right extremity of the lake is Geneva,—the city of Calvin, and Servetus, and Rousseau; and directly across the lake is Deodati, once the residence of Byron, whose stormy genius wrestled with the lightnings which leaped from the peaks of Jura in the rear, while he heard

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* See the illustrations to the two preceding chapters.

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* See Frontispiece.

"Jura answer from her misty shroud
Back to the joyous Alps, who call to her aloud."

Or, let us ascend the cliffs which break the ocean surges at Nahant, and look down upon the towering billows as they roll upon the shore frothing with rage and sending up a continuous roar along the beach, or howling in the windings of the long clefts which split the beetling escarpments of rock.

Or, let us ride upon a ship at sea, when sunset gleams illumine the summer sky, and the phosphorescent fires mark the trail of the vessel till it blends with commingled sea and heaven. The brave ship rises and sinks with the dying swell of yesterday's storm, and steams onward toward her port. There is no sound in heaven or earth, but that which ascends from our little world. The infinite depths of space are populous but voiceless. The unsearchable depths of ocean are populous also, and voiceless. There disport the mute monsters whose dominion has never yet been invaded by man. There swarm the microscopic inhabitants whose tiny structures are as studiously and tastefully elaborated as if each were to be exhibited at the world's millennial exposition. There pass to and fro the unspoken messages which weave the web that binds the continents in amity. * * * But let the winds arise from their slumbers. * * * Midnight drops her murky mantle on the deck. The sea rolls and heaves and groans in an agony. Fierce spirits of the air howl among the cordage, and flap their rain-soaked pinions against the fluttering shrouds. The good ship leaps in air, then plunges with a groan beneath the curling, angry lip of a wave. The water boards the deck, and again retreats from the well battened hatchways. The flashes of an angry heaven make visible the tumult of sea and ship, and the threatening thunders, louder-voiced than the terrific howl of the waves, descend upon the terror stricken inmates of the cabin. Terrible, but glorious, is the storm at sea. The man who remembers a storm in mid-Atlantic possesses a fortune of æsthetic and moral influences.

Such beauty, such sublimity, are spread over land and sea to awaken the æsthetic sense and ensphere us in a medium of inspiration and joy. Happy is he who is sensitive to the myriad revelations of beauty which blossom from land and sea and sky. Were no other reward of culture attainable, all our pains would be compensated in a spirit trained to interpret nature and drink the inspiration of her beauty. Hear what one of the acknowledged ornaments of your sex is reported to have said of the beauty of the world: "To me it seems as if, when God conceived the world, that was poetry; he formed it, and that was sculpture; he varied and colored it, and that was painting; and then, crowning all, he peopled it with living beings, and that was the grand, divine, eternal drama."*

The beauty of humanity is another sort of physical beauty. It is bathed, however, and suffused and lighted, in its full development, by beauty of soul. There is no presence which mute and motionless speaks with such subduing power as the human mien. In its different moods, as terrible as the stormy sea, or as placid as the summer lake, or fathomless and suggestive as the blue depths of the sky. Here is my dark-eyed boy in his fourth summer; look on him in sleep; in outline what a masterwork of the divine artist; but within the gracefully chiseled form is all the mystery and the beauty of life warming his tinted skin, throbbing visibly through all his frame. * * * Now his lids are parted; those dark eyes look out from the land of the spirit — avenues to a mysterious world — a depth too deep for even imagination to explore. Oh, who has not gazed into those deep, melting, trustful eyes of childhood, and tried to penetrate their soft, bewitching, spiritual haze? There is a light and warmth of heaven in them still, and I feel it, and I sigh to think the fire of heaven is destined to be smothered by the ashes of a mortal life. I could worship as well as love the boy, for I feel that he is yet a divinity.

I know not whether the spiritual is so inseparably blended with the material in man that it becomes impossible to contemplate beauty of form apart from the beauty of the informing spirit; but I am of the opinion that the perfect human figure is the most beautiful blending and interfusing of lines of beauty which nature has ever produced. An ascetic theology may affect to despise the body,— may even learn to contemn it with profane and lamentable sincerity, but it is the workmanship of a divine artist, which he has pronounced suited to be the casket of his own likeness. I would not dare yield to the Greek in admiration of its divine beauty. I accept the verdict of the cultured intelligence of all the ages. The perfect human form we shall never cease to admire. The beautiful face or figure sheds a gratuitous joy on all beholders.

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*Charlotte Cushman.

The instinct to seek to appear beautiful is universal. Some of us are obliged to content ourselves with approaching the beautiful only so far as to become pleasing. None need fall short of this. But whosoever can become beautiful may regard himself divinely called to be beautiful. Beauty and duty chime as well in substance as in sound. The ambition to be beautiful is not only right,— it is ennobling,— it is obligatory. But beware of counting mere personal beauty the chief end of life.

The prerogative of supreme personal beauty belongs to the sex which, by unanimous impulse, we pronounce gentle. I have beforehand the undivided verdict of my own sex when I pronounce a beautiful woman the most perfect expression of the ideal of physical beauty. Beauty of person spiritualized by a quick responsive intelligence, beaming and sweet with a transparent benignity of soul, crowned with the queenly mien, and sceptered with the regal gait which are her birthright, makes woman the mightiest moral power in existence. The history of the world is my voucher for the statement.

> "The power o' beauty reigns supreme
> O'er all the sons of men."
>
> *James Hogg.*

The most exquisite attempts of the painter have not reproduced her tints and tones and shadows. The most ideal efforts of the sculptor have not conferred warmth and softness and life upon the cold marble. The most divine eloquence has not portrayed the depth of feeling and purpose in the fathomless spirit of her eyes. The most angelic muse has not given expression to the native poetry of her movements. She is the spirit of painting, and sculpture, and eloquence, and poetry, incarnate. She is the arch-triumph of all the arts in a single achievement.

It seems to me that such a creature should be happy with her possessions and her prerogatives.

This supreme expression of beauty, it must be observed, is not, after all, the product of purely physical qualities. This highest beauty is never discovered save when the reflex of a cultured soul blends in the features of the face. Mere physical beauty of person we recognize and admire, but supreme, commanding beauty receives its crown and halo from the radiant soul within. A cultured mind gives charm to the face, and a gentle and disciplined and benignant heart shines winningly through features which are not of classic mould.

Hear what one of the closest of modern observers of human nature writes of one of his ideal characters:

"There is a beauty too spiritual to be chained in a string of items; and Julia's fair features were but the china vessel that brimmed over with the higher loveliness of her soul. Her essential charm was,—what shall we say?—Transparence.

"You would have said her very body thought."

Modesty, Intelligence, and, above all, Enthusiasm, shone through her and out of her, and made her an airy, fiery, household joy. Briefly, an incarnate sunbeam."[*]

Beauty of person, then, is something which may be cultivated. Hence the aspiration to be beautiful is not a vain one; were it so, kind nature would not have implanted it in our hearts. I do not speak at random when I affirm that women with cultured minds and hearts excel in beauty those who remain ignorant and perverse. From the day when a course of intellectual and spiritual training begins, you may detect an improvement in personal attractions. I appeal to every teacher for confirmation. And now I wish to say more: culture confers not alone spiritual beauty, but also *physical* beauty, which in turn becomes a more perfect vehicle for the beauty which is spiritual. Mind and body act and react. The cultured daughters of the city and the town are more comely than the unlettered drudges of the alleys and of the frontier. This condensed lesson I would have placarded in illuminated letters upon the wall of every lady's boudoir: *As you would be beautiful, be intelligent, be good.*

How vain, then, are rouges and dyes and other cosmetic inventions! Beauty is not made of paint and powder; it is the temple which health builds for a pure, bright spirit; or, as St. Clement of Alexandria says, "Beauty is the free flower of health."[†] The tricks of misguided vanity cannot be passed unnoticed. They have woven a thread continuous through the web of feminine history. Hear what Aristophanes catalogues among the artifices of his Greek countrywomen two thousand years ago:

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[*] Charles Reade, *Hard Cash*, Boston ed., p. 6.

Clemens Alex. Pæd., Bk. iii, ch xi.

> "Snoods, fillets, natron and steel,
> Pumice-stone, band, back-band,
> Back-veil, paint, necklaces,
> Paints for the eyes, soft-garment, hair-net,
> Girdle, shawl, fine purple border,
> Long-robe, tunic, Barathrum, round tunic,
> Ear-pendants, jewelry, ear-rings,
> Mallow-colored, cluster-shaped anklets,
> Buckles, clasps, necklets,
> Fetters, seals, chains, rings, powders,
> Bosses, bands, olisbi, Sardian stones,
> Fans, helicters." *

We have no such catalogue to offer as suited to our own times. There is but one item on which the female mind seems generally agreed as essential to the adornments of the present day, which is not in some sense tolerable to the fairly balanced masculine judgment. That one thing, I am pained to say, strikes more fatally at female beauty than would be possible for all the "snoods" and "fetters" and "helicters" enumerated by Aristophanes. This one thing is "banged hair,"—a style to be seen in perfection among Eskimos and Australians, and one which contributes materially to impart to the women of those races their characteristic expression of unmitigated idiocy,—a fashion which ought to disappear from civilized society as fast as nature permits the hair to return to its divinely appointed condition.

Manly beauty is, even more than womanly, a reflex of the inner adornment. Homer, speaking of the true original beauty of man says,

> "At first, he was a lion with ample beard." †

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* Aristophanes, *Thesmophoriazousæ.*

† *Odyssey*, iv, 457.

Physically he seems adapted to command respect rather than admiration. His beauty is symbolical. As the knit muscle expresses strength, we fear it as a foe, or trust it as a friend. The strong chest expands like something safe to lean upon. The capacious front is the natural symbol of god-like wisdom for command and security. The features acquire interest as they become interpreters of the calm or the tumult, the tenderness or the rage, the joy or anguish, which reigns within the temple. The manly models of Greek sculpture excite our admiration only as they recall the beauty of heroism, or fidelity, or patriotism, or some other noble virtue. The Apollo Belvidere, so often assumed as the type of manly beauty, has neither the moral symbolism, the proportions, nor the mien of the manly ideal. What beauty the statue possesses is feminine,— a good Apollo, but not a man. The stalwart strength and intellectual resolve of manly character are not expressed. In the famous cartoons of Raphael we have the opposite extreme. Muscle is developed to brutal proportions. The rayless, prehistoric countenances above such extravagant frames are the most fitting harmonies which I have been able to discover,— for instance, in the "Miraculous Draught of Fishes." How much truer an instinct has Raphael disclosed in his Sistine Madonna.

Age has its own beauty. True is it, indeed, that the beauty of old age is also, to a large extent, symbolical. It is a picture of a time grown venerable. It is a symbol of experience and wisdom. It is our admonition of the decay and silence which come to all of us. It is a sunlight gleam from another world through a rift in the clouds which obscure our mortal vision. But old age cannot be all of this unless it follows a cultured and virtuous life. The old age of the ignorant and the hard-worked degenerates into decrepitude, and wrinkles, and imbecility. A peasant woman of seventy or eighty years, with face cross hatched with wrinkles, and antique coif drawn down over her time-blasted brows, with no past memories worthy to rehearse, and no present interests to inspire a gleam in her withered eye, and lift her bent form for outlook into the affairs which stir the world to-day, is not an object of beauty, whatever of interest or domestic affection may hallow her presence. But what a different picture is presented by such octogenarians as Mary Somerville, Caroline Herschel, William Cullen Bryant, Peter Cooper, Victor Hugo, or Guiseppe Garibaldi. Ah, it is intelligence and serenity, and urbanity, the memory of life improved, the expectation of heavenly welcome, which make old age beautiful. It is the well-developed brain which blossoms as a century plant when the light of another world begins to descend upon our heads.

Still other forms of beauty enter our souls through the senses,—the beauty of motion and the beauty of sounds. Those curves which agreeably impress the æsthetic sense impress it with a livelier sentiment when they become the paths of moving objects. The swaying of a willow in the wind; the undulations of a field of grain; the circling movements of the quadrille or waltz; the serpentine course of a rivulet across the plain; the spray rising from a waterfall; the course of a ship on the water, or of a bird in the air,—these are familiar examples of the beauty of motion. Music is the beautiful addressed to another sense. The occasion does not permit me to raise the question, What is the subjective nature of music? Has music an existence independent of sound? Would music exist if there were no precipient beings to receive harmonious vibrations? I venture the opinion that the rhythm of music is one element of its pleasing effect; and then, as tone, the product of synchronous vibrations, is but another sort of rhythm, it may be that musical rhythm and melody and harmony yield us æsthetic gratification for the ultimate reason that all are measured, harmonious impressions upon the sensorium, like the equal intervals in a file of soldiers or other objects regularly repeated. This would be one step toward a generalized expression of the nature of the beautiful in sound and in certain forms, and I think that in its broadest signification the beautiful may be formulated under the principle of harmony or correspondence; but the discussion must be passed by.

It is not alone in formal music that sound assumes the character of the beautiful. From the chimes of cathedral bells to the jingling of the merry sleigh-bells, or the "drowsy tinkling" of the cow-bell in the distant field; from the solo of a Lucca to the warbling of a wood-thrush, or the purling of a mountain trout-brook; from the majesty of a sacred chorus to the distant bleating of the homeward herd at sunset, or the cheery chattering of a bevy of school-girls on a picnic; from the deep bass of the organ to the hoarse voice of the thunder, or the moaning of the south wind in the pine trees,— these all are easy transitions to forms of sound which in themselves are beautiful, and are often doubly pleasing from the fond associations with which they renew our pleasures past.

I must pass from forms of beauty which reach us through the sensuous perceptions; and lest I should seem to leave the treatment of the subject too incomplete, I must remind you of two modes of the beautiful which reach us through the internal perception. The first is the BEAUTY OF TRUTH. It is given especially to the scholar to discern and enjoy it. To look out beyond the little sphere which bounds our personal life, and discern a universe so designed that every feature strikes a responsive chord in us; to discover a God,—a heavenly father, as the reality after which our human souls had longed; to consider the admirable system of correspondences and adaptations through which every object which exists contributes to the well being of every other; to contemplate the unity of truth, as in the science of quantity, where the same result comes out whether sought by logarithms or by sines, by trigonometry or by equations; to think of the majestic unity of the system of worlds, all knit indissolubly in a cosmic organism, so that, whether sun or planet, star or nebula, each is a living picture from the life-time of every other,—such revelations of the unity, the grandeur, the vastness, the unchangeableness of truth, enter the soul which opens its portals for them, and attune every fibre to a song of ecstacy. This is the *Te Deum* of the intellect. This is the beatitude of science.

The second mode of the beautiful revealed to the inner sense is MORAL BEAUTY. Wherever right maintains a manful conflict with wrong; wherever the stout and brave arises for the defense of helplessness and innocence; wherever the martyr for freedom of intellect or conscience hurls defiance at his persecutors, or reveals a fortitude stronger than the fear of death; wherever friend sacrifices himself for the love of his friend; wherever the mother watches and waits in anxious vigils by her sick child's bedside; wherever the father, for his family's sake, welcomes the care and labor which waste his powers and sap his life-blood; wherever a stricken heart pours its libation of tears and rekindles a tender memory over the tomb of buried love,—in all these acts of blessed and beautiful human life we feel that there is drawn up from the deep susceptibilities of humanity something which is divine and infinitely beautiful. Oh, how blessed to attain such beauty as this!

In the reason of every one exists the idea of perfect virtue,—unspotted purity. We think of that ideal purity with a feeling of admiration,—with a feeling of aspiration. Oh, who has not sighed for a nearer approach to that ineffable excellence?

"Nearer, my God, to thee."

Who has not wept that with all his aspirations and aims he has fallen so far short of this standard? I never encountered a pure and guileless character but I felt like falling in worship before it. And my reverence is heightened when sinlessness has been won in the conflict of temptation and the storm of passion.

Our human life is embellished and beautified with pictures of immaculate purity blended with helpless innocence. The little children which throng our pathways and cling to our necks,—beautiful messengers which come out of heaven through the clouds which settle about the celestial heights, touch our hearts and melt them with the sweet radiance of their innocent faces, utter a few phrases which live more imperishably in our memories than the aphorisms of the wise, and then unclasp our necks, close their eyes and return to heaven,— are they not the very person of beauty revealed in the flesh?

I remember,— I shall always remember,— the heart-moan of a dear friend,— a stalwart friend, but touched with the tenderness which bereavement brings,— shedding his tears over the buried remains of his little daughter: "She was not transformed," he said, "she was translated. She was always an angel; how she came from heaven I never knew, but she was amongst us; she spoke our language, but always with a meaning more than the words conveyed. We gave her a name, but she was never called by it. She named herself. Undoubtedly she remembered the name she bore in heaven. There was always a fragrance of heaven about it. No one could take it upon his lips but in love. She bears that name in heaven again. In my nightly roamings," he said, "through that other world, which is not beyond the stars, but just behind the veil of life, I have heard that name uttered by gentle lips,— sisterly lips,— in whose every accent I recognized voices I had once known in my waking hours."

Oh, there is a beauty in tears,— whether of the widow pleading with heaven, or the stout heart crushed in a mysterious bereavement.

The world is redundant in beauty. Human life is radiant in beauty and redolent of heaven; and the invisible world, whose threshold only thought can cross, and whose fabric is built of the eternal truth, is the apocalypse of the beautiful to the eye of intelligence. Wheresoever beauty abides, there is cause for human joy. I love to forget the toils and sorrows of life, exultant in the bliss of glimpses which come from a life on the sunny side of all earth's gloom, for even the clouds, when they must weep, are still radiant with the light of heaven.

You will pardon a few parting sentences,— such as manhood may speak to youth. I would leave you these words of encouragement. I would they might be words of inspiration. Hard trials will come, but be beautifully brave; be beautifully resigned; be beautifully hopeful. Seek for the brightness of the world. You have placed open the doors of your souls for the admission of knowledge, and culture, and discipline, and gentleness. These guests of your soul have garnished it, and added beauty is shining from your eyes and beaming from your features. Let the doors stand open. Give generous hospitality to these angel agencies of loveliness of character. Press into the presence of the beautiful and hold living communion with it,— the harmonious, the graceful, the brave, the faithful, the devoted, the patient, the hopeful, the pure. Think on them. Learn chief of all to admire and strive after the beauty of character exemplified in Him who knew no guile, and who offered his life for love of a world which had rejected him. Then, after having enjoyed the beauty of God's world, you will leave behind you the memory of a beautiful life, and renew existence in the smile of Him whose unfailing love, in earth and sea and heaven, in song and smiles and tears, in life, and even in death, reveals itself in the BEAUTIFUL.

THE OLD AGE OF CONTINENTS.

"TIME writes no wrinkle on thine azure brow," said Byron, as he laid his hand upon old ocean's mane, "Such as creation's dawn beheld, thou rollest now." Byron had wandered in poetic reverie among the vestiges of ancient empires, and sighed to think how the greatest works of human genius dissolve to dust. He had saddened, perhaps, at the thought of his own inevitable fate, and fancied that in the "deep and dark blue ocean" only could be discerned "the image of eternity." Had Byron learned that the seven hills themselves, on which had sat imperial Rome, were but the vestiges of an older order of things, and that even solid continents have crumbled like the Coliseum, a deeper tinge would have colored his habitual melancholy. Happy had it been for Byron could he have practiced the belief in the existence and eternity of his own spirit, which he sometimes confessed, for there is nothing but spirit which bears "the image of eternity."

The "everlasting hills,"—the fancied types of solidity and endurance,—are but a passing phase in the history of terrestrial matter. The mountain's sullen brow has frowned where quiet vales expand themselves to the morning light, and fields and cities smile where rugged cliffs and abysmal gorges long delayed the advent of a race that had been heralded through the geologic ages.

Even continents have their life-time. They germinate; they grow; they attain to full expansion and beauty; they fulfill their mission in the economy of matter and of life; the furrows of senescence channel their wasted faces, and they return to mud and slime whence they were born. The very substance of the solid floors which underlie the soil of American freedom, is but the dust of continents decayed. As modern cities are sometimes built from the ruins of ancient temples on whose sites they stand, so the dwelling place prepared for man by the hand of Nature is but the reconstructed material of a more ancient continent, the work of Nature's "'prentice hand." The vertical thickness of fifty thousand feet of sedimentary strata measures the depth of the rubbish accumulated from mountain cliffs and continental slopes that have been transformed by the wand of time. We sometimes forget that the total volume of our stratified rocks is but an index of the denudations and obliterations that have been wrought. Much calcareous material has, indeed, been yielded by the sea, but the sea first filched it from the land.

The revelation made by every formation which we study, from the bottom to the top of the Palæozoic series, points to the north and northeast as the origin of the stream of sediments that spread over the bottom of the American lagoon which stretched as a broad and shallow ocean from the rising but yet submarine slopes of the Alleghanies on the east, to the embryonic ridges of the Rocky Mountains on the west. Northeastward of the present continent have undoubtedly existed supplies of incalculable magnitude of which the merest vestiges remain. The geologist leads us to the region north of the great lakes and the St. Lawrence river, and points out the Laurentide Ridge as the nucleus of the eastern portion of our continent. Around its bases have been wrapped layer upon layer of accumulating sediments, till the ocean has been banished from a broad belt of his ancient dominion. But this, instead of being the real nucleus of the American continent, is but the vestige of that nucleus. How vastly inferior in height and breadth, and especially in north-eastward prolongation to that primordial continent whose crumbling shores and denuded slopes afforded material for the broad sheets of Silurian, Devonian and Carboniferous strata which stretch a thousand miles in every direction! Where lay the dissolving lands which furnished substance for the ponderous Alleghanies? It must be that vast areas have disappeared from view. Though I believe, with Dana, that the modern continents were outlined in primeval time, and the ocean still reposes in his ancient bed, we must not be too exact in the enunciation of our faith. The Aleutian Islands, stretching from Alaska across the North Pacific, are but the protruding vertebræ of an eroded ancient ridge which welded the Orient to the Occident. New England, Gaspé, the Labrador elbow,—these all reach toward the site of an obliterated prolongation,—a friendly arm of the American continent stretched out to greet the continental arm of Europe extended from the British Archipelago toward America. Newfoundland, Cape Breton, Prince Edward's, Anticosti,—these are but the highest summits of that wasted ridge, as Ireland and Great Britain are the relics of the ridge responsive to this upon the European side. The submarine plateau, along whose back creeps the great Atlantic cable, though sunken ten thousand feet beneath the reach of further denudation, is but the stump of an ancient continent that has been gnawed to the very foundations.

It is interesting to reflect that advancing civilization has at last reëstablished the amicable intercommunication of two continents which had been embraced, perhaps, in the ordinations of primeval time.

Such are the reminiscences of a wasted continent of which the Laurentide nucleus is but a trace. We stand upon this venerable relic of long-forgotten lands, and the current of time sweeps by, bearing upon its dark bosom the wrecks of other continents born of earthquake and flood in the later ages of terrestrial history. But though we intend to rescue from oblivion the tales inscribed upon these disappearing ruins, thought lingers fondly and reverently and inquiringly around the scorched and beaten brow of this Laurentide Ridge. What was its mother? And where was its birth-place? These ancient granites and thickly-bedded gneisses,— thrice baked and crystallized by the fiery ordeals through which they have passed, — bear, nevertheless, the ineffaceable traces of old ocean's work. Here are the lines of sediment which betray the parentage of these hardened and storm-beaten rocks. Back into another cycle of eternity imagination plunges in search of that more ancient land that was reconstructed in this "primordial" ridge. To say that it did not exist is to say that old ocean could pile up masonry without a supply of bricks and mortar. In the realm of thought that earlier land looms up, but its bounds and borders are obscured by the overhanging fogs which haunt the early twilight of time. The skies themselves are strange, and our science gropes for the data which shall fix the latitude and longitude of this undiscovered country. Was it still another pile of rocks reared by the labors of water? Or was it a mass of ancient slag, the first-born products of primeval refrigeration of a molten globe? There was an earliest land,—a dome of lava just cooled from the fiery abyss of molten matter,—a film of frozen dolerite or pophyry stretched around the fluent globe,—a solid floor on which descended from the gathered clouds the waters which formed a sea without a shore. There must have been a time when the surges were first summoned to their work. To assert, with Hall, that it is idle to dream of such a beginning, because, forsooth, the traces of the morning's work have been obliterated by the operations of mid-day, is to plunge into the fallacies of a philosophy fashionable in some quarters, and narrowly assert that there is no knowledge but that which the senses certify.

We turn now our thoughts down the stream of time, and note the relics of later revolutions. Not for eternity were laid the floors of the Old Red Sandstone strata which once stretched, perhaps, from the Catskills to Massachusetts Bay. Not for eternity were reared the Appalachian summits whose elevation celebrated the close of Palæozoic time. The Catskills are but a pile of horizontal strata; spared by the gigantic denudations which scraped the face of New England to the bone, and washed away a third of the Empire State. The continuation of the Catskill strata is discovered again in Pennsylvania, Western New York, Ohio, and Michigan. Who shall undertake to delineate the topography, the drainage, the vegetation, the populations of that ancient New England surface which now lies strown, perhaps, from the bottom of Long Island Sound to the farther shore of New Jersey? Who shall write an epic on the fortunes of that mythical forefather land? The summits of the Alleghanies, geologists tell us, have settled down some thousands of feet. Their huge, protruding folds, plaited together in compact array, have been planed down to their innermost core; and from the chips have been produced the lowlands of the south Atlantic border,—like the waterfront raised in a modern city by carting down the sand-hills in the rear. The very coal-beds interwoven in their stony structure are but the fossilized swamps of an ancient continental surface that has disappeared,—clothed once by forest trees whose family types have dropped from the ranks of existence, and populated by those strange amphibians,—half fish, half reptile,—which, like the fabled Colossus, bridged the chasm between two dominions.

There was a long and mediæval time in American history of which our records are mostly lost. The coal lands had been finished; the atmosphere had been purged; the Appalachians had been raised, and from their bases stretched westward beyond the destined valley of the Mississippi an undulating upland but lately redeemed from the dominion of interminable bogs. The western border of this land skirted a mediterranean sea through which, probably, the Gulf Stream coursed, in certain cycles, at least, from the tropics to the frozen ocean. Here was accumulated a soil; here descended genial rains; here flourished tropical plants, and here wound majestic rivers, fed by their hundreds of tributary streams. All traces of this continental surface have disappeared. Terrestrial animals must have populated the spacious forests; insects uttered their sleepy hum amid the luxuriant foliage of evergreen conifers; sluggish Labyrinthodonts crawled from beneath the shade of perennial Cycads, and mailed and armored fishes fought against the invasion of more modern types in waters bordered by forests of plane-trees, poplars, and a multitude of other forms already assuming the aspects of the finished age of the world. This ancient home of vegetable and animal life spread over the States of Ohio, and Indiana, and Illinois, and Kentucky, and all the region contiguous to these. River channels were dug whose very locations we seek in vain. Cities and villages and verdant farms now stand upon sites above which waved a somber forest whose every trace has been wiped from the face of the continent, while the very soil in which their roots were bedded has been transported to the Gulf of Mexico. Those broad and fertile plains performed their part in the history of terrestrial preparations, and like the pictures on the lithographer's stone, they have been completely erased, to be succeeded by the next scene in the succession of continental landscapes.

There was an ancient surface on which was growing the cinnamon, the plane-tree, the magnolia, and other tropical and sub-tropical forest-growths. It stretched from the borders of the Atlantic to the slopes of the Pacific, and from the Mexican Gulf to the shores of the frozen ocean. It was the American continent now first extending its limbs after a protracted embryonic growth. We are not positively informed whether to the east of the Mississippi this continent was the continuation in time of that which resulted from the changes closing the Carboniferous Age; but we well know, since Dr. Newberry's explorations, that in the far west, over the Colorado plains, was a vast region which had but recently emerged from the bed of ocean waters.* Here lies the "great central

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*J. S. Newberry, in Ives' *Colorado Expedition*. See later and more detailed information in the government reports, especially the *Atlas of Colorado*, plateau" of the continent, formed of the vast stony sheets, piled one above the other, which have never been tilted from their approximate horizontality since the beginning of Palæozoic time. And here, again, we are led to inquire: Whence so vast an amount of sedimentary material, strewed through Palæozoic, Mesozoic, and Tertiary ages, over the bottom of that broad continental ocean? Where now those wide-extended lands or towering mountain ridges whose dissolving substance yielded sand and cement for the Titanic masonry of a new-made continent?* Wherever it was, and whatever it was, the "tooth of time" has gnawed it to a skeleton. It is a continent of the past, worn out by the uses to which nature has subjected every continental area in turn, and which to-day are wearing out and destroying the land on which, for the passing time, the human race, like those which have preceded it, has found a momentary foothold.

But the great central plateau, once freshly formed from the older lands which were exhausted in its formation, is in turn but the ruins of a former fruitful and smiling region. For nearly a thousand miles in breadth, and probably two thousand miles in length,—stretching from the Mormon monarchy southward far into the republic of Mexico,—a frightful desert reigns. Naked rocks and

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compiled under the direction of Dr. F. V. Hayden, and the accompanying text; also Capt. C. E. Dutton's *Geology of the High Plateaus of Utah*, prepared under the direction of Maj. J. W. Powell.

*Mr. Clarence King, in his *Survey along the Fortieth Parallel*, has shown that a great western continent existed during Palæozoic time in the western portion of the Great Basin or present Nevada plateau, which was mostly submerged at the end of Carboniferous time. By the end of Jurassic time, the Sierra Nevada and Basin Ranges to the east had become uplifted. At the end of the Cretaceous, the Uinta and Wahsatch ranges appeared, together with some new portions of the Rocky Mountains. It is probable that the denudation of these regions supplied a large part of the sediments which went to build up the vast plateau regions in Colorado and Utah.

thirsty sands, and shrubless, treeless wastes are only diversified by yawning chasms and dismal cañons and Cyclopean walls rising in the distance from height to height, like the gigantic steps by which the monster Typhon scaled the realm of Jove. Once on a time a thousand mountain streams leaped down upon this plain, and gathered themselves by degrees together, and grew into the majestic Colorado, which glided quietly, or by occasional falls, into the gulf of California,—itself now shrunken to half its former dimensions. At intervals, expanded crystal lakes, turning their mirror surface toward the sun as cheerfully as ever smiled Lake George. The incumbent atmosphere drank copiously from the abundant waters, and returned its deluges of thanks in cooling summer showers. Thus herb and shrub and forest tree rejoiced, alternately, in smiling sunlight and refreshing rain. The great central plateau was the prairie region of the continent. It was this, perhaps, while the region east of the Mississippi was lying a worn-out desert waste, unrenovated since the age which witnessed the elevation of the Alleghanies. But the ceaseless erosion of running streams, for thousands of years unnumbered, has sunken the water-courses of the central plateau to the depths of hundreds and thousands of feet; every lake is drained; the local supply of moisture has disappeared; the streams have withered in their ancient channels; vegetation has retreated to the mountain slopes; the giant Cereus alone rears its specter form like a ghostly visitant to the graves of its former kindred.

There is reason to believe that before the advent of the glacier epoch nearly the whole of North America was a worn-out continent. It is possible, however, that most of the denudation of the central plateau has occurred during and since the prevalence of glaciers over the northeastern portion of the continent. As to the region east of the Mississippi, however, we know that it was an upland continental area, while even the rocky foundations of the great plateau were accumulating in the bottom of an ocean. It is difficult to conceive how this eastern region, on the advent of the glacier epoch, could have presented a surface greatly less eroded and desert than that which the Colorado valley presents to-day. Vegetation, undoubtedly, held possession of the borders of the water-courses; and it must be remembered the conditions of atmospheric precipitation were, even at that time, as much superior to those of the arid western plains as they now are. Nevertheless, the local sources of humidity had mostly dried up, and the ancient rivers had sunken hundreds of feet into dismal gorges that were destined to be their graves. Traces of these fossil river-channels are frequently encountered. Dr. Newberry has pointed out their existence in Ohio; General Warren has indicated their presence in Wisconsin, Minnesota and Dakota. The latter has also shown that a depression of the northeastern region of the continent, which is even now in progress, has turned northward and eastward the drainage of Winnipeg and other lakes which once poured their surplusage through the Minnesota and Mississippi rivers.

The great glacier, in its movement over the surface of the Northern States, together with changes of level and the action of torrents of water springing from the bosom of the dissolving ice-field, has totally transformed the face of this portion of the continent. The ancient river-courses have been filled; the rugged, eroded and naked rocks have been reclothed with fresh materials for vegetable sustenance; the surface is again strewed with vapor-making lakes, and plants and animals, and man himself, find in the renovated continent the fitting conditions of their prosperity.

But this last stage of things can no more be permanent than that which has preceded. The present continent is destined to experience the symptoms of senescence and decay. Every year the untiring streams transport new portions of the land into the bottom of the ocean. The Alleghanies mingle their tribute to the sea with that which is yielded by the distant Rocky Mountains.

"The Father of Waters
Seizes the hills in his hands and drags them down to the ocean."

From age to age the mountain-tops are descending to the plain; the rounded hills are shrinking; the gorges are deepening; the changing vegetal growths are responding to the changing conditions; the present is passing away; once more the wrinkles of age will furrow the face of the continent, and the populous organisms which had found a fitting home upon it will exist no more. The valley of the Mississippi is no more fertile than was once the valley of the Colorado. We read in the present condition of the latter the destiny which awaits the former. The slow but inevitable steps are in progress before our eyes. The "image of eternity" can be discerned neither in the ocean, which is but an instrument for the accumulation of solid land, nor in the rocky foundations of the land, which from cycle to cycle are re-wrought into the masonry of renovated continental surfaces. Man himself, who populates but one of these successive "time-worlds," is destined to yield to impending revolution. Human history is but a scene in the moving panorama of life, and its term is no less certain than that of the Mesozoic saurians. It may be the last scene, but it will not be perpetual. Its limitations are inscribed upon the scroll of the geologic ages, and proclaimed in the events of the passing hour.

Neither can the series of continental renovations continue without limit. The time must come when the earth itself will be "in the sere and yellow leaf." The forces which hoist a continent dripping from the depths of a recent ocean will be weary of their labors. Already they act with greatly lessened energy. These, like all other forces, are seeking rest. Equilibrium and stagnation are the goal of all mechanical activities. Uplifted mountains, denuded continents, obliterated seas, appearing and disappearing races,—these are all but the incidents of the progress of all terrestrial forces to a state of ultimate repose. Not only has nature fixed the limits of our race; she has equally staked out the duration of the present terrestrial order, and proclaimed in the ears of all intelligences that the flow of events which we trace so clearly to a remote beginning is destined, in the distant future, to be merged again into ancient chaos. So the perpetuity of the cosmical order is not insured by the laws of matter alone. An omnific Arm begins, sustains, controls the evolutions of the successive cycles of material history.

The indications of continental decay at which we have glanced are worthy of further study. I shall, therefore, resume the theme and point out other cases of continental wastage which have resulted in obliteration.

OBLITERATED CONTINENTS.

THE mute and inanimate rocks, to one who questions them, are rich in teaching and suggestions. They speak not; they bear no record in any human language; yet, in reason's ear, they are vocal with instruction; to reason's eye they are all luminous with the thought which beams from the hieroglyphics inscribed upon their pages.

It is a further lesson of wastage which we propose now to study. The rocks are *not* imperishable; and their very disappearance is a text for reflection. I stand beneath a beetling cliff,—perchance the beetling sandstone cliffs of Chautauqua county, in New York, or of the "Pictured Rocks" at Lake Superior, or, perchance, those banded and variegated courses of crumbling masonry which wall in the valley of the Upper Mississippi,—and there I perceive not only that a portion of the rocky mass has been removed, but also that which remains is merely the *débris*, the ruins, of some former rock or rocks which were ground to fragments to build up the foundation which constitutes these massive walls and these overstretching shelters. If I scrutinize any of these cliffs, I find them composed of grains of sand. It is a quartz sand. In those words I imply that a quartz rock has at some time been broken into fine fragments. Some agency has assorted the fragments and brought the finer ones together here, in these magnificent ranges of sandstone precipices,—in these extensive sandstone formations, which underlie whole counties,— which underlie, or have underlaid, states broad enough for an empire.

How few of us have reflected in this direction. The very rocks which underlie Chicago or New York are a pile of ruins. Everywhere, the rocks are almost universally *old material made over*,— who can say how many times made over? The geologist formerly discoursed of fire-formed rocks; and regarded granite and its associates as rocks that had assumed their present condition from a state of fusion. Now we are persuaded that granite, like sandstones, has had a sedimentary origin. It was once a mass of sand and mud upon a sea-bottom. Heat has subsequently baked the materials, and almost obliterated the ancient lines of stratification. The rocks now admitted to be of igneous origin are few. Only ancient and modern lavas are fire-formed rocks.

How vast, then, has been the destruction of the land in ancient times! The entire mass of the solid crust of the earth — save only the lavas — must be taken as the measure of the wastage or denudation of the older lands. Reflect upon the thickness of these strata,— reaching, perhaps, a hundred thousand feet, and enwrapping the entire globe. Only the oldest layers or formations are absolutely continuous; and the very newest occur in patches of limited extent; but the newer as well as the older underlie all the seas, and the mean thickness is so vast as to convey a vivid idea of the amount of work which has been done by geological agencies in diminishing, or even obliterating, continental masses whose sites are now lost, or known only from surviving vestiges.

It is an interesting thought,— an impressive thought,—

OBLITERATED CONTINENTS

THE mute and [illegible] them, are rich in [illegible] speak not; they [illegible] yet, in reason's [illegible] reason's eye they [illegible] beams from the [illegible]

It is a further [illegible] to study. The [illegible] very disappearance [illegible] neath a beetling [illegible] [illegible]ffs of Chautauqu[illegible] [illegible]ed Rocks" at [illegible] [illegible]d variegated [illegible] [illegible]n the valley of [illegible] ceive not only [illegible] removed, but [illegible] *bris*, the ruin[illegible] ground to [illegible] constitute[illegible] shelte[illegible]

extensive [illegible] land, arid land, formed of the
ties,*—which [illegible] globe. This has disappeared by
enough [illegible] from beneath. It is possible

How few [illegible] one portion of this primitive lava-
very rocks [illegible] the level of the ancient ocean. It
of ruins [illegible] Archæan land (built of the ruins
old [illegible] But I deem it more probable
made [illegible] materials have been more than once
formed [illegible] whatever the truth may lie in this re-
rocks [illegible] of the oldest rocks which we
[illegible] evidence of an obliterated continent.
[illegible] Archæan continent itself. On its own
[illegible] of enormous magnitude. The
[illegible] material rests like lumber piled on
[illegible] slopes of the Laurentide region the
[illegible] meeting place seem thousands of feet
[illegible] levels as they now exist. Clearly, the
[illegible] at one time a mountain chain which
[illegible] down to moderate levels by the action of
[illegible] Turn toward the eastward prolongation
[illegible] of Canadian hills north of the St. Law-
[illegible] land abuts against the coast of Lab-
[illegible] the navigator brings us new suggestions.
[illegible] plummet has felt of the ocean's bottom all
[illegible] Newfoundland to Ireland. There is the
[illegible] plateau." On this rests the great Atlantic
[illegible] this shallow water,—along this submerged
[illegible] not discover the stumps of the ancient pro-
[illegible] the Archæan land? Are not Newfoundland,
[illegible] New Brunswick, and the smaller islands of
[illegible] remaining patches of a continental prolon-
[illegible] has been worn down by the waves? And

are not Ireland and the smaller contiguous islands on the European side the vestiges of the remote extremity of the Archæan land of America? And were not Great Britain and America once united in bonds of granite? And is not the telegraphic cable which reunites them an instrument for the fulfillment of a destiny?

Who can declare whither the substance of the Archæan continent has gone? Where are the cubic miles of stuff which have been taken from the higher altitudes of the Laurentide range, and from that Atlantic prolongation which is now reduced to a submerged stump? I think we may safely say the sandstones of Potsdam, in New York, are formed from Archæan material. The cliffs at Little Falls and Albany are formed of materials contributed by the older land. I think we may say that the vast beds of Silurian, Devonian, and Carboniferous strata account for some of the material missing from the Archæan continent. There are the Alleghany mountains,— or better, the entire Appalachian chain,— built out of coarse materials brought from the northeast. We know they came from the northeast because the materials grow coarser in that direction. The lighter fragments — the sands and clays — are transported farthest from the shore. It was the sea which performed this work of transportation. It was the sea which conspired with the storms of heaven in tearing down the old land to convey it into the territory of the United States. There, in a long stream, stretching from New England to Alabama, the "dust of a continent to be" was laid down in the bottom of the ocean.

Now, in this search for continental relics, turn southward. There are the West India islands, composed also of ancient rocks, perhaps mostly, certainly not altogether, of rocks of the same age as those forming the Laurentide hills. I think it probable another continent spread over the Caribbean Sea at the time of the continental connection of America and Europe. There, where that primitive continent lay, are Cuba, now, and Jamaica, and the lesser Antilles,—hundreds in number,—the rags and tatters of a land once continuous—perhaps beautiful—perhaps enduring until the middle ages of geological history, and then populated by the grotesque forms of reptiles, which were, in that time, the highest and the dominant type of beings upon the earth. That West Indian continent overlapped a small portion of South America. Guiana was annexed to that which has become the West Indies. All other parts of South America were beneath the sea. The Andes—ah! the Andes were building—receiving, probably, the self-same material which was disappearing from the West Indian continent. Stretching from Cuba northward was the ocean, whose northern shore was in Canada,—in later times in central New York. Here, where rise the cliffs which we ignorantly style "everlasting," was then the empire of the ocean. There, where Neptune now holds almost undisputed sway, rose ranges of granitic mountains, which have melted into sediment. Tennyson has happily rendered the thought:

"There rolls the deep where grew the tree.
O earth, what changes hast thou seen!
There where the long street roars, hath been
The stillness of the central sea.

"The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands,
Like clouds they shape themselves and go."

In Memoriam, cxxi.

Turn next to the opposite side of the globe. Southeast of Africa is a group of islands which Milne-Edwards first designated as the remnant of a wasted continent. Madagascar, the Isle of France, the Isle of Bourbon, and their associates, seem to be the vestiges of an obliterated land, which the French zoölogist proposed to call the Mascarene continent. Lemuria is a name now generally employed to designate an obliterated land which embraced the Mascarene continent, and stretched eastward over a portion of the site of the Indian ocean,—perhaps far enough eastward to embrace the East India Islands. There, at least, seem to be the remnants of an ancient land which fulfilled its destiny before the broad plains and stupendous mountain chains of Asia had first received the sunlight. This lost continent is named Lemuria, because there is evidence that it was the original, the central home of the Lemurs, the lowest of the monkeys, from which all higher types of four-handed animals are descended. Lemuria was a central land for animal and vegetable life. Here, it is fancied, the human species began its existence, its diverging streams extending themselves to all other lands, and developing upon them the various races of men as we know them. In Africa, human beings became Negroes and Hottentots; in Australia, Australians and Papuans; in Hindustan, Dravidians; in Eastern Asia, Mongoloids; in central and western Asia, the Mediterranean race. The theory implies that the progenitor of the Mediterranean race made his appearance long, very long, after the first human being appeared in Lemuria. In consequence of these speculations, the lost continent of Lemuria possesses a high degree of interest. There organization first reached its culmination. Thence, as a center, the modern tribes of plants and highest animals have diverged into other parts of the world.

But let us return now to America. On our northwest coast we reach a point within 39 miles of Asia. Behring's strait, which separates the two continents, is a channel geologically modern. There was a time when an isthmus connected the lands now dissevered by a strait. America was then, like Africa, the prolongation of Asia. Over this isthmus traveled the Hairy Mammoth from Siberia, and left his teeth and bones all the way from Asia to the Gulf of Mexico. Over this isthmus came the Mongoloid man, who settled America, and developed the Mexican and Yucatese and Peruvian civilizations; and, in other regions, became the red Indian, the Eskimo, and the Aleut. Yet we have evidences of a wider communication between Asia and America. The whole of Behring's sea is formed of shallow water. On its southern boundary we find a precipitous descent into the bed of the great Pacific. Here is another continental stump. Here is another telegraphic plateau. May the time soon arrive when human enterprise will take nature's hint and reunite the mother land with our own. But there are the Aleutian islands; what means that wonderful chain arching from the Alaskan point across the north Pacific to Japan? Are not these the vestiges of the mountain barrier which bounded the ancient continent of the north? What are these volcanic islands but the smoking chimney-tops of another Andes, sunken in the watery depths?

These are the relics of continents which have disappeared. Their substance has entered into the upbuilding of other lands, as the pyramids have yielded material for the construction of modern cities. There rise the Himalayas, whose very bricks bear the records of the Lemurian age. There rise the Rocky mountains, enriched by the pillage of a land whose misfortune it was to perish before human pens existed to celebrate its beauty. There tower the Alleghanies, only as a majestic dirt-heap resulting from the destruction of the North Atlantic continent. There rises the Andean rampart of South America, reared for the benefit of the human age, but at the cost of a prehuman land of verdure and beauty whose very rags we style "the beautiful Antilles."

There was an ancient land whose name has long survived in tradition as Atlantis. It has been lost to human eyes and to human knowledge for more than thirty-five centuries. Plato, in the *Timæus* and in the *Critias*, has preserved for us a tradition said by him to be embodied in a lost poem by Solon, who lived two hundred years before Plato, in the sixth century before Christ. Solon pretended to have learned the tradition of Atlantis from the Egyptian priests, from whom he received much of the learning which made him one of the "Seven Wise Men" of Greece. This lost land was situated beyond the Pillars of Hercules, and was the seat of a civilization far superior to that of the cave-dwellers who inhabited Europe. It possessed, according to Plato, cities and palaces and temples. It supported a vast army, and, nine thousand years before Plato, dispatched a military expedition for the conquest of northern Africa. Only Egypt successfully resisted. Plato's date of 9600 B.C. must be taken in an oriental sense. The Athenian kings, Cecrops and Erechtheus, mentioned as contemporaries of this campaign, are known to have flourished 1582 and 1409 B.C. Theopompus tells us a similar story respecting the people of Atlantis;

but it varies sufficiently to indicate a distinct source of information. The priests of the ancient inhabitants of Gaul, also, known as Druids, and the successors of the Cyclopes, or cave-dwellers, possessed traditions collected by Timagenes and preserved in the "Fragments of Greek History," by Ammienus Marcellinus, according to which that country was invaded by a numerous people who came from a distant island. Marcellus also informs us that there were formerly seven islands in the Atlantic ocean near the European continent, which we now recognize as the Canaries. He adds that the inhabitants of these islands preserved the memory of a much larger island, Atlantis, which for a long time exercised dominion over all the other islands of the Atlantic. Other historical mention might also be cited tending to convince us that, at a remote period, a large island existed to the west of the straits of Gibraltar, and which, by some convulsion of nature, or by the slow erosion of the elements, has been extinct for 3,500 years.

Now the sounding-line of the mariner comes again to contribute its data to the solution of the puzzle of Atlantis, —"the fabled Atlantis," as we please to call it. Some of my readers will recall the newspaper announcement, a few years since, that Commander Gorringe, of the U. S. sloop *Gettysburg*, had discovered a bank in the Atlantic ocean, thirty-two fathoms beneath the surface of the water, which was covered with a growth of living pink coral. The Gettysburg Bank is less than a hundred miles from the coast of Portugal. A hundred miles west of this is the Josephine Bank, in 82 fathoms of water. These observations led to the collation of soundings by other government vessels. In January, 1873, the British ship *Challenger* sounded over the same and contiguous regions; and in July, 1874, the German ship *Gazelle*. The result is the discovery of another continental stump. It stretches from the Madeira islands to the coast of Portugal, and from the Canaries to the African coast, and thence to Gibraltar. The Canaries and the islands of Madeira, Desertas, and Porto Santo, are undoubtedly the relics of a former continent.

Behold the fable of Atlantis converted into modern fact! — as Schliemann has made the myths of Homer solid history. This sunken land lies exactly in the position of the ancient Atlantis. The Guanches, or original inhabitants of the Canaries, were the remnants of the nation which sent its conquering armies against the Berbers and the Tyrrhenians and the Gauls. But the Guanches had lost all memory of the warlike deeds of their ancestors; they were even ignorant of the existence of the continents of Europe and Africa, and declared to the discoverers of their islands, "God placed us on these islands, and then forsook and forgot us." These Atlantidean people were known in Europe as Iberians. They belonged to the family of Hamites, and were members of the Mediterranean race, to which we belong.

We have no need to plunge beneath the sea and explore for fossil continents to be convinced that continents have their old age. The records of wasted areas are illuminated by the daily sun. The Alleghanies have been lowered nine thousand feet. When, at the close of the Coal Period, the crust of the earth yielded to the long-increasing strain, huge folds were uplifted from Vermont to Alabama; and some of them attained an altitude of 15,000 feet. Since that fearful throe of nature, the elements have been busy taking down what the forces of upheaval had reared. Cubic miles of the Alleghanies have been reduced to sand. The proud summits of the mountains lie strewed along the humble shores of the Atlantic States.

There stand the Catskills,—a pile of horizontal leaves of red sandstone. Abruptly, on either slope, the rocky strata terminate. There was a time when they continued eastward across the valley of the Hudson. The wear of chiliads of years has carted the formation away. There was a time when they continued westward across the entire southern border of the state. Those cliffs at Panama, in Chautauqua county, are a remnant left as a specimen of the formation, for the edification of the student of nature. The huge blocks of the "Rock Cities" of Alleghany and Cattaraugus counties in the same state are samples left for the encouragement of geologists in those regions. Other specimen rocks of the Catskills may be seen in places from Delaware county westward. It is fearful to contemplate the immensity of the mechanical power which could carry away the surface of half a state to the depth of a thousand feet. Here, at fifty cents a cubic yard, would be a perennial job for the contractor of the "New York ring."

Without leaving the same state, let me take the reader to the ridge road which runs along the south shore of Lake Ontario. Here the broad sheets of sandstone, limestone and shale which underlie the state come to the surface and terminate in an abrupt cliff. Beyond is Lake Ontario. What has become of the missing continuation of these formations?

Go to the Niagara gorge; see how the faithful industry of an agent "as weak as water" can accomplish results which defy the capacity of human engineering. Here was the Niagara, as busy in Mesozoic time as to-day—as busy in Cenozoic time as if its work were just begun. There is the living gorge, and there is the old gorge, buried in its grave. Buried with materials obtained by tearing to pieces some other land,—buried by that agency which piled up *these* hills of gravel and sand which everywhere diversify the surface of our northern states; which brought these acres of loose deposits from the worn and wasted sides of northern hills; which dipped its flinty plow-share in the back of the surface rocks of every northern state, and ripped up the rubbish which has filled many an old river channel, and plastered over many an unsightly scar which the wear of time had cut in the face of the land; the same agency which scooped out many of the lake basins, and scalped the hills for a booty to bestow on a desolated and sorrow-stricken country. It was the continental glacier which did this work; and the desolated country was a land that had been weathered and worn by the erosions of unknown cycles of time,—a land gashed with the deep-cut gorges of long-wearing streams; gullied by the summer torrents of many geologic periods; robbed of its slender soil by the prolonged denudations of the surface; a worn-out continental expanse,—a land exhausted in the service of the beasts which had held dominion here through Cenozoic time,—but a land destined to receive a higher being, and now renovated by such thorough-working agencies for his reception.

He who has visited the flourishing city of Nashville finds it situated in the bottom of a basin,—a great natural basin, scooped in the rocks of central Tennessee, whose sides are layers of Lower Silurian, Upper Silurian, Devonian and Carboniferous rocks. It is a basin a hundred miles in diameter and a thousand feet in depth. On the east and the west, on the north and the south, the same succession of rocks rises in the bounding wall. There can be no error in my conclusion that these formations were once continuous from side to side. Here, then, is another example of the wastage of the land. The central mass of Tennessee was needed to build up the Cretaceous and Tertiary formations as a foundation for Alabama and Mississippi.

Still, the most gigantic examples of denudation occur in the far west. The cañons of the Colorado, made famous by the explorations of Newberry and Powell, are river-gorges cut six thousand feet deep through the rocky formations of the country. All the lateral affluents of the Colorado have dug similar trenches. They intersect the surface in every direction, and render it almost impassable. Of these gorges Joaquin Miller writes:

> "Down in a cañon so cleft asunder
> By saber stroke in the young world's prime
> It looks as if broken by bolts of thunder,
> Riven and driven by turbulent time."
> *Songs of the Sierras.*

The soils are washed away; the naked rock bakes in the summer sun, and no cooling shower mitigates the fervor of the climate. This desert of the continent was once its garden. The ruin has been wrought by the same agencies which have desolated Palestine till the white bones of the hills protrude where vineyards once blushed, and olive trees cast their delicious shade. It was the same agency which is preying to-day upon the farms of New York and New England, and is planning to skin the soils again from the sterile rocks, and leave the continent as lean as before the "reign of ice."

In that western country, but farther north, in Wyoming, Major Powell has discovered an enormous fault or break through the rocks. On one side the ponderous crust of the earth was uplifted 25,000 feet,—more than four miles. The reader may picture a vertical wall four miles in height. He may imagine himself standing at its base and looking upward. Its summit is dimmed by the smoke of distance. Its summit is half the time immersed in the clouds. He need not imagine such a cliff; it is not there; it has been planed down; the leveling tendency of nature would not tolerate such inequalities. Twenty-five thousand feet of solid rocks have been moved away.

These are examples of erosion on the existing continents. I could point to many others,—to the dissolution of the hills of Texas, and their distribution over the plains nearer the Gulf-border; to the wearing away of the eastern coast of the United States; to the isolated hills rising 800 feet along the valley of the Amazons, standing as vestiges of an extensive formation, which, in times geologically recent, has covered the valley; to the enormous erosion of the continental mass in the neighborhood of the mouths of the Amazons and Para; to the evidence that the North Sea has been dry land since Tertiary time, and that the Thames was then a tributary of the Rhine; to the proof that the English channel has been excavated since the advent of man in Europe; to the Chinese record of hydrographic changes in China, which have shifted the positions of great cities hundreds of miles in relation to the sea.

But I must close the citation of these evidences of the invasion of old age upon the beauty, the symmetry and the habitability of continents, by raising the question of the rate of erosion of their surfaces. If we look about us, we discover the evidences of great change in the configuration of the hill-sides within a few years. One summer's rains plow unsightly gullies in our cultivated fields and across our streets. These changes, resulting from local transfers of earthy material, are filling lakes and draining marshes, and transforming the hills; but it is only the transfer of the continental substance to the ocean's bed which threatens the total obliteration of continents. The sediment carried down by *rivers* is an exponent of the efficient wastage, and the rate of disappearance of the land. The sediments of the Mississippi have been carefully measured by Humphreys and Abbott, government engineers. The river discharges annually sufficient earthy material to form a mass one mile square and 268 feet deep. In other words, it is sufficient to extend the bar at the mouth of the river 338 feet annually. They also estimate that the material of the entire delta of the Mississippi may have been deposited within 5,000 years. These quantities of sediment are vast, and impress us with a conviction that the solid land is disappearing at a rate which is almost alarming. But these volumes of sediment are gathered up from so vast an area that the lowering of any particular square mile is insignificant in any limited time. New York contributes something to this deposit through the Alleghany and Ohio rivers. The Rocky Mountains send their quota to mingle with the mud floated from New York and Pennsylvania; and all the great tributaries of this great artery of the continent reach out their myriad fingers over the farms and plantations, the hillsides and the mountain gulches, to filch, as fast as they can, the fleeing soil from the possession of the cultivator and owner.

> "The Father of Waters
> Seizes the hills in his hands, and drags them down to the ocean,
> Deep in the sands to bury the scattered bones of the mammoth."
> *Evangeline.*

Professor Croll estimates the lowering of the lands through denudation to amount to one foot in 6,000 years. The basin of the Ganges, however, has lowered one foot in 2,300 years. On the contrary, Mr. Reade, a civil engineer, estimates that England is lowered by denudation only one foot in 13,000 years. He calculates that 500,000,000 of years must have elapsed since the first sedimentary rocks were laid down in Europe,—an estimate evidently absurd, and throwing suspicion over his other estimates, since Sir William Thompson has shown from physical principles that 100,000,000 of years are all the time allowable since the beginning of incrustation on the earth. Similarly, Col. Forshey calculates that the Mississippi river would fill the Gulf of Mexico in 1,000,000 of years.

All calculations are merely approximate. I am persuaded, however, that the conclusions of Croll and Reade respecting the rate of denudation are quite below the truth; while, on the other hand, I suspect that the estimated age of the Mississippi delta by Humphreys and Abbott is quite too small, as I would hold that the opinion of De Lanoye, who assigns 6,350 years as the age of the Nile delta, is also too moderate in its allowance of time.

From this outline of the facts we perceive that continents are wearing out. Each continental area abides its time, and gradually yields to the destructive agencies which are always at work. Each period of the world's history has had its continental surfaces for the accommodation of its appropriate populations. When the period has reached its close, the continents have been exhausted, and renovating agencies have been summoned to restore their pristine condition. When impaired beyond recuperation, the powers of nature have been invoked for the uplift and utilization of new continental masses, which through ages had been building under water, out of the stolen materials of older lands. So our own farms and mountains will ultimately disappear, and the footing of the human race will vanish beneath their feet. A wasted continent and a wasted world must cease to retain its organic populations. Thus we see a promise of release of our race from the planet to which it is now confined.

A GRASP OF GEOLOGIC TIME.

HOW shall the mind obtain relief from the oppressive idea of eternity which confronts it on every page of geologic history?

We seize upon a thread of relations, and follow it back through the whirl of terrestrial revolutions till the head swims and the vision grows dim, and the symbols of duration cease to excite any adequate emotions,— as when words of eloquence fall upon ears of lead. We lift the veil which conceals the future, and cast our glances down the vistas of *coming* time; but again our thought is paralyzed, and we sink into the depths of eternity as stupidly as the reptile withering in his rocky crevice.

Oh, for an expanse of thought that shall permit us to seize upon the years of God! This world of ours, we have been told, instead of being the result of creative energy put forth six thousand years ago, is the product of revolutions that have exhausted millions of years in their consummation. The twenty or thirty populations which have passed like shadows over the surface of our planet, have each had a duration at least equal to that of the existing population, whose beginning stretches back into the fogs of mystery and myth. When imagination has wandered back to the beginning of this succession of life, it finds itself at the conclusion of an older history, during which the powers of fire and water were struggling with each other for supremacy upon the globe. Still back of this elemental contest we behold the scenes of the undisputed reign of fire, when the terrestrial globe was a self-luminous orb. And yet deeper in the infinitudes of the past we are forced to contemplate the matter of the earth and of all her sister planets a blended blaze of ethereal flame. While we stand paralyzed and wondering in the presence of such unmeasured flights of time, the geologist, the astronomer and the physicist open their mouths in unison to assure us that, from the beginning to the end, this mass of matter has been wasting its heat in infinite space as fast as the wings of ether could bear it away; and that every phenomenon of terrestrial history, from primordial light to the last spring tempests, has been only a consequent or a concomitant of this progressive cooling. And when we ask how long the duration of this work, they reply that the earth has cooled only one-fourteenth of a degree in the last twenty-five centuries.

Even when we narrow our observations down to the compass of the closing events of terrestrial history, we stand amazed before the revelation of eternity. The renovation of the continental surface by the great glacier, and the floods which attended upon its dissolution, marked the last great revolution which passed over the surface of the land. Yet of all its vicissitudes, nothing has been preserved to us by the history or traditions of our race. It lies back in the unmeasured realm of the geologic æons. Since the disappearance of the glacier, geological results which, to the eye of a generation, seem stationary, have been accumulated in aggregates of stupendous magnitude. The gorge of Niagara, seven miles long, one thousand feet broad, and two hundred and fifty feet deep, is thought by some geologists to have been worn out by an agency which, save in extraordinary cases, demands a century to render its results perceptible. Even if we only claim that portion of the gorge below the whirlpool as the record of post-glacial work, and then reflect upon the almost stationary position of the falls since first observed by civilized man, we receive a profound impression of the length of the passing geological period. Much of the peninsula of Florida, within times geologically modern, has been undergrown by a coral reef and added to the domain of the land. The delta of the Mississippi has taken the place of a broad estuary which penetrated deep into the heart of the land. There are those who would have us believe that even the monuments of human activity date back a thousand centuries, while the decline of the continental glacier, the extinction of the last fauna, the wastage of the pre-glacial surface of North America,— these are events which stretch æons upon æons into the remoter past.

Now let us gaze the ages steadily in the face. Let us see if it be impossible to take in the compass of a geological period. Let us seek for a unit of measure with which we may gauge the cycles of terrestrial evolutions. Let us grope for a parallactic base-line of known dimensions, from which we may take the bearings of events gleaming down upon us from primeval time.

Not all great geologic events date back to a high antiquity. Here has been the first error in our premises. Man did not come upon a world in which history had closed. He came in the midst of the progress of events. Man himself was one in the series of events. Great vicissitudes preceded his coming; great vicissitudes have even followed his coming. We have thought that when man appeared, the work of geologic agencies had been completed, and that his race was destined to contemplate things in a state of fixity, or moving in ever-repeated cycles; hence every momentous revolution in terrestrial affairs of which we trace the records must have antedated the advent of man into Europe and Asia,— must have antedated the first appearance of man on the earth. It must stretch back into a remote antiquity. When, therefore, we discovered, as we must discover, that man had been the witness of vast geologic changes, we first, as by an impulse, declared that man's existence mounts also to an antiquity measured by scores of thousands of years.*

We have learned another lesson in the primer of science. The great tide of events which we have witnessed sweeping down through the ages of palæozoic and later geologic time is now sweeping past our very doors. It is the same tide: we ourselves are borne upon its bosom. In our brief day we may note a few of the vicissitudes which swell and perpetuate the current.

What man of adult years does not know some reedy bog which in his boyhood was a skating pond? Who that has attained the years of grandsire has not seen meadowland in spots which he once knew as reedy bog? The alluvial meadow has grown from the reeking marsh; the marsh emerged from the shallow lake-bottom by the slow filling of the depression. The whole work is one within the grasp of human comprehension. But the little lake was a vestige of the last inundation of the ocean, which followed the glacial visitation. So the great glacier almost looms into view.

The traditions of the Greeks preserved the memory of an ancient submergence of the Scythian plains. The vast steppes of Russia and Siberia, like the prairies of the Mississippi Valley, were once the bottom of comparatively shallow seas or lakes. The tundras of northern Siberia appear to have been inundated since the period of general glaciation. This is also true of the polders along the coast of the German Ocean. The Magyar puszta and the regions of the tchornosjom or black earth of Russia seem to have been produced by a former extension of the waters of the Black Sea. The black earth or prairie region of southern Russia covers an area twice the size of France. It appears that an obstructed outlet of the Black Sea dammed the waters to such an altitude that the Black and Caspian and Aral were one,— a greater Mediterranean spreading over the most fertile areas of the Orient, — which were thus preparing, as the American prairies were at the same time preparing, to become the garden of the continent to which they belong. This lacustrine region is the ancient Lectonia. In the progress of events an earthquake-throe shivered the barriers of the Thracian Bosphorus, and the Oriental prairie-land was drained. The fable of the floating Symplegades perpetuates the memory of the relative transpositions of land and water. History preserves but an imperfect record of this great hydrographic revolution. The story which tradition bore down to the reach of history had grown vague and defective. But tradition, which ever delights to reproduce the marvels of the past, not only retained its hold upon the great fact, but yielded to history some data which have found a permanent record. Herodotus, the "father of history," has supplied such geographical details as enable us to trace the limits of land and water about the northern shores of the Black Sea, as they existed several centuries before our era. Any one who will take the trouble to consult Rawlinson's *Herodotus* will find a map of the Scythian plains in which the Sea of Azof possesses still an extent approaching in area even that of the Euxine itself. History has not brought us equally explicit tidings of the contraction of the Caspian and Aral Seas; but geological and topographical evidences proclaim with unmistakable clearness the recent retreat of the Caspian on the north, over a distance of 240 miles of country depressed below the present sea-level, and many hundreds of miles of territory but little elevated above it. Indeed the opinion prevails that in times geologically recent the Caspian was joined to the White Sea and the Sea of Obi, and the Aral formed part of the same body of water. When the Caspian flooded the valley of the Volga the Euxine filled the valleys of the Don and Dnieper. The plains between these two rivers were then sea-bottom as well as the Ponto-Caspian flats north of the Caucasus and stretching from the Sea of Azof and the Don to the Caspian Sea. Thus, in times comparatively modern, a vast region stretching from Turkestan to the Danube and from the Elburz Mountains to the White Sea and the Sea of Obi has constituted a part of the water-surface of the earth. Here has been a geological emergence of almost half a continent, the later stages of which mankind stood by to witness, and the recollection of which lingered in tradition and then in history till science has arisen to bring full confirmation.*

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* Compare the author's *Preadamites*, ch. xxvii.

There are indications not a few that the delta of the

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* See Von Baer, *Kaspische Studien*, and Wood, *The Shores of Lake Aral*, 1876; Sir R. Murchison and Sir H. Rawlinson, *Jour. Roy. Geogr. Soc.*, 1867; Roesler, *Die Aralseefrage*, 1873.

Nile and a greater part of the desert of Sahara have been the bed of the Mediterranean within the human epoch. Aristotle refers to the growth of the Nilotic delta in his own times; and Strato and Strabo recognize the probability that it had been covered, in times not very remote, by the waters of the Mediterranean. Herodotus says that in the time of Menes the valley of the Nile was a swamp below Thebes, and he expresses the opinion that "the country above Memphis seems formerly to have been an arm of the sea." All this is sustained by the salinity of the water still retained in the deeper deposits of the delta. Not only the delta but extensive sand-covered regions to the west are generally admitted to have been in comparatively modern times the bed of the sea. When recently drained, many parts of this ancient sea-bottom probably presented, like ancient Lectonia and the prairies of Illinois, a soil of high fertility, which sustained human populations during the lifetime of a nation; but, like other continental surfaces which have fulfilled their part in the sustentation of a race, the Egyptian and Libyan plains have deteriorated to a limit beneath the needs of civilization, and civilization has sought out fresher areas on which to continue its march.

The traditions of every nation preserve the memory of a widespread and destructive deluge. One such deluge occurred in the Orient, and swept off the contemporary populations. Our biblical records assert that "the waters prevailed upon the earth one hundred and fifty days," that they covered elevated mountains, and that all living creatures in the country (*hââretz*, the whole region) perished. Berosus, the Chaldee historian, speaks of a general deluge in the time of Xithuthrus; and this testimony is confirmed by the cuneiform inscriptions of the Izdubar legends, as deciphered by the late George Smith,—a story which must have had a common origin with the biblical narrative. The sacred books of the Hindoos preserve the record of a great deluge which occurred about the time of the Mosaic flood. Among the Chinese, also, are records of one or more floods. Confucius represents the Emperor Jas as exercising his authority or power in effecting the retreat of a deluge which completely inundated the plains and lesser hills, and washed the feet of the highest mountains. We have no assurance that this was the same deluge which exists in the mythology of Greece, but it may have been. Thus Ovid, in his beautiful account of the Deluge of Deucalion, says:

> "Jamque mare et tellus nullum discrimen habebant;
> Omnia pontus erant. Deerant quoque littora ponto."*

Even the Mosaic narrative of Noah, and the Chaldean story of Xithuthrus, reappear in the *Metamorphoses:*

> "Jupiter, ut liquidis stagnaque paludibus orbem,
> Et superesse videt de tot modo millibus unum,
> Et superesse videt de tot modo millibus unam,
> Innocuos ambos, cultores numinis ambos,
> Nubila disjecit."†

This deluge was occasioned by the "opening of the windows of heaven," and the breaking up of the "fountains of the great deep," or, in the highly poetical words of the *Metamorphoses*, Neptune, coming to the aid of Jove, summoned the rivers to his palace, and commanded them to pour forth their strength.

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* Here is a translation for the unclassical reader: "Now sea and land presented no distinction. All places were sea; nor had the sea anywhere a shore."

† "Jupiter, when he sees the world covered with stagnant pools, and sees one man surviving of so many thousands, and one woman surviving of so many thousands, both sinless, both worshipers of divinity, disperses the clouds."

> "Hi redeunt, ac fontibus ora relaxant,
> Et defrænato volvuntur in æquora cursu.
> Ipse tridente suo terram percussit; et illa
> Intremuit, motuque sinus patefecit aquarum."*

There can be no doubt that a destructive inundation, general throughout the East, occurred in the early history of the Mediterranean race. Neither is it to be doubted that well-known natural causes have been adequate to the production of such an inundation. As the upheaval of some portion of the Alps, in the period just before the advent of man, sent a destructive inundation over a large part of Europe, so the uprising of some portion of the mountains of the Caucasus † may have been accompanied by the emission of such quantities of watery vapor as by condensation to deluge half a continent. Such a visitation, by whatever natural cause effected, has been witnessed, if we may trust abundant traditional and semi-historical evidence, by the early representatives of our race in western Asia.

The hydrographic changes which have transpired in northern China are among the most extensive and remarkable that have been witnessed by man. On all except the most recent maps of China, the Hoang Ho, or Yellow River, is represented as having its outlet in the Yellow Sea, near the city of Hwaingan, in latitude 34°. During the Taiping rebellion, a few years since, the course of this mighty river was changed from the neighborhood of Kaifung, three hundred miles above its mouth, and a new channel was established, leading into the Gulf of Pe-chili, three hundred and eighty miles in a straight line northwest of its old outlet. But this channel has not been established without the most terrible inundations of the low and level delta of the Hoang Ho. This delta covers all the northeastern portion of China south of the "Great Wall" and north of Hangchau and Honan.

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* "They return and open the mouths of their fountains, and roll in a torrent unrestricted to the sea. Himself, with his trident, strikes the earth; it trembles, and by the motion opens the secret place of the waters."

† According to Dr Abich. the upheaval of all the higher portion of the chain has involved strata of Tertiary age.

Nor has this been the first nor the greatest occasion when this unbridled and destructive river, fed by the melting snows of the Mongolian plateaus, has deserted its bed and sought out new outlets to the sea. According to the oldest Chinese records, the Hoang Ho, previous to the time of the "Great Yu," which was about 2,200 years before Christ, pursued a totally different course from the place of its crossing the northern boundary of China into Mongolia. At this place it emptied into a vast lake half the size of the Persian Gulf, which, in turn, connected eastwardly with another vast lake, stretching to Peking, from which the drainage found an outlet into the northwestern angle of the Gulf of Pe-chili, near Tien-tsin. The "Great Yu" — whether this be the name of a monarch or the personification of a great nation — turned the river southward four hundred miles, between the provinces of Shensi and Shansi, to Fuchau, whence he conducted it eastward two hundred and seventy-five miles to Kaifung. At Kaifung the river divided, one main outlet stretching east-southeast to the Yellow Sea, and several others winding toward the northeast and debouching in the Gulf of Pe-chili. The area included between the new and the old channels was not less than 280,000 square miles, or about equal to all the New England and Middle States of our Union.

Since the time of Yu, the Hoang Ho has made extensive changes in its bed not less than eight times previously to the last change. The great delta has been cut in every direction. Sometimes the exclusive outlet of the river has been by one or more mouths in the Gulf of Pe-chili; at others it has been exclusively in the Yellow Sea; and at still others the river has had outlets in both directions. The Yang-tse has participated to some extent in these wanderings. In the meantime the Yellow Sea and the Gulf of Pe-chili have been filling up with sediments. In many places the shore-line has traveled one hundred feet per year for the last two thousand years. In other places the change is not over thirty feet per year. A recent writer calculates that the sediments of the three great rivers of China would fill the Yellow Sea and the Gulfs of Pe-chili and Lian Tung in 24,000 years.*

The increase of land is probably in part due to a slow rising of the eastern border of the continent. Such a rising is felt at numerous places. The island of Tsung-Ming at the mouth of the Yang-tse, which now has a population of half a million, did not exist in the fourteenth century. Beaches of recent shells are seen in the south of China, many feet above the present sea-level. Similar beaches are found on the Japanese islands from fifty to one thousand feet above the sea. On the island of Formosa, such beaches occur at an elevation of 1,100 feet. A Dutch fort, built in 1634, upon an island detached from Formosa, is now some distance inland, and stands in the center of a large city.

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*H. B. Guppy, *Nature*, xxii, 448. Mr. A. Woeikoff thinks this period should be extended to 28,000 years. (*Nature*, xxiii, 9.)

Such are indications of a gradual emergence of the eastern border of the continent, producing a very considerable extension of the land. The growth of the land is, however, only approaching a condition which has heretofore existed. The records and traditions of the Chinese carry us back to a time when Corea was continuous westwardly with the mainland. The Gulf of Pe-chili and the Yellow Sea had no existence. The great delta-plain extended to the Japanese islands. Indeed, the hydrographic maps of the Chinese waters demonstrate that the continental surface extends strictly to the submerged ridge running from Nipon through the Liu-Kiu islands to Formosa. Here is the proper rim of the basin of the Pacific. Traditions exist of the former extension of the continent far toward this limit. Here, then, is an area equal to the half of Europe, over which the forefathers of the Chinese extended their migrations, on which they built cities and founded dynasties, and which mankind have lived to see sunken beneath the Pacific, and the memory of which had been almost forgotten.*

The geological history of eastern Asia diverts our attention to great hydrographic changes which have taken place in the region southeast of China, and not improbably since man has been an occupant of the earth. Southeast of Asia lies the great Malay Archipelago. It includes the great islands of Sumatra, Borneo, Celebes, the Philippines and New Guinea. Still farther southeast is the continent of Australia. The numberless islands of this archipelago

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*Accessible information on geographical and hydrographical changes in China is contained in Professor R. Pumpelly's memoir in the *Smithsonian Contributions to Knowledge*, xv, art. iv; *Amer. Jour. Sci.*, ii, xlv, 219; and in papers by A. S. Bickmore, *Amer. Jour. Sci.*, xlv, 209, and Martin, *Amer. Jour. Sci.*, xlvii, 100. See, also, Von Richthofen, *China*, 12, 85-87.

are mostly but the higher eminences of an ancient prolongation of the Asiatic continent that has been sunken by volcanic action or wasted by the agencies of erosion. Southeast of the Indo-Chinese peninsula there are no soundings until we reach the line connecting Celebes with Java. This is a distance of twelve hundred miles from the mouth of the Cambodia river. The width of these shallow soundings is seven hundred miles. From Java the zone of shallow soundings extends north-northeast to a point beyond Luzon, a distance of about two thousand miles. Now, all around through Sumatra and Java to Mindinao and the Philippines is a chain of active and extinct volcanoes from whose craters incalculable volumes of molten matter have been ejected, even during the historic period of our race. The island of Java alone is the site of forty-seven of these volcanic vents. To supply eruptions of such magnitude has undermined the solid crust throughout all the neighboring region. The southern angle of the continent has sunken till its valleys lie from fifty to one hundred fathoms below the level of the sea, while its mountains stand even up to the chin in water. The sunken area is four thousand miles in length from east to west, and thirteen hundred in breadth from north to south.

This subsidence, accelerated by atmospheric and oceanic erosions, has taken place during the modern epoch of geological history. Not only birds and insects, but reptiles and ponderous quadrupeds, that once had liberty to range over the continental surface, are now restricted to isolated islands, whose limits are even yet becoming narrower. The eastern portion of the Malay archipelago, however, is separated from the western by a deep ocean channel.

New Guinea, Ceram and Timor present the same alliances with Australia as the other islands do with Asia. As the species of the Indo-Malayan archipelago exhibit affinities which reveal their derivation from types occupying the Asiatic shore, so those of the Austro-Malayan archipelago declare their descent from Australian progenitors. Even the human races reveal the same affinities and bespeak the same migrations. We are led thus to the following conclusion.

At some period in the history of our species, after the brown stock of races had become differentiated from the black, the older black race or races held possession of the Australian continent in all its former extent. At the same time the brown Malayan Mongoloid wandered down the Asiatic peninsula as far as Borneo, and found its further progress intercepted by the deep sea dissevering the two continents. Each race continued to occupy its own continent, and as the ocean gradually encroached, held possession of the emergent elevations, till science opened its eyes upon questions of geology and race and distribution, and reproduced the vicissitudes of a continental history which man, though a spectator of the whole, had long since forgotten.

This account undoubtedly holds true for the central masses of faunas and races. But no human race has been completely barred by the intervention of channels, however deep or broad. We find accordingly that representatives of the black stock of men found their way to the islands of the Indo-Malayan archipelago, and survive, crowded and dominated by the Malays to this day. These are the Aëta of the Philippine islands. To these we should add the Mincopies of the Andaman islands. In the opposite direction the brown stock survives in the natives of Madagascar. The conjecture is admissible that their ancestors migrated from the Malayan peninsula over a land connection then existing. The evidences convince us that the movement was in this direction, and do not permit us to assume that the Malagasies are survivals of the primitive Malayan stock.

Mankind have lived in the midst of the grand phenomena of terrestrial revolutions. There was a time when the Orient was united to the Occident by an isthmus which then held the place of Behring's Strait. This may have been at the time when the bottom of the Yellow Sea was dry land. Then the Siberian Mammoth wandered into North America. Then probably the ancestors of the Aztecs made the discovery of the continent, and in the lapse of ages wandered down the whole length of the coast to Cape Horn. The vicissitudes of ages brought extinction to the mammoth, but the American Indian perpetuates his memory in tradition.

Since man first appeared in Europe the North Sea has been dry land, and Great Britain has been joined to the continent twice or more. According to Professor James Geikie's interpretation of the facts, man was present before the beginning of continental glaciation, and Great Britain was then a part of the continent. Then followed a subsidence of 1,200 or 1,300 feet, which isolated Great Britain from the continent as at present. With a reëlevation general glaciation of all the northern and middle portions of Europe came on. Then another subsidence occurred, which in turn was followed by an elevation which joined Great Britain to France and Holland. The bottom of the North Sea became dry land, and Scandinavia also was connected with the British islands. Most of the Baltic Sea constituted a great lake. The land had even a greater northern extent. Continental Europe stretched to Spitzbergen, Iceland and Greenland, and now, as the climate was genial, European types of plants and animals ranged to those far northern shores. The Rhine and the Weser discharged into the ocean in the latitude of the Faröe islands; the Thames, the Great Ouse, the Humber, the Tyne, the Tweed and the Dee were all tributaries of the Rhine. At this epoch man found his way into Great Britain. This was the period immediately following the dissolution of the continental glaciers. It was succeeded by a subsidence and a colder, humid climate. Great Britain became insular. Marshes and bogs prevailed throughout northern Europe. Another elevation was attended by the return of a milder climate and a luxuriant growth of forests. Bronze found its way into Great Britain. Then still another subsidence occurred, and a period of wet weather. Iron was introduced. Thus with increasing dryness of climate prehistoric times passed into historic.*

It may be that northern Europe has not experienced so great a number of oscillations in Post-Tertiary times; but all geologists are agreed that since the beginning of the Glacial Age Great Britain has been twice continental and twice insular. It is generally agreed also that within the same interval the North Sea has been dry land. That Greenland, Iceland and Spitzbergen have been joined to Europe is a firm doctrine of science, and the only question is whether the connection occurred in Post-Tertiary time or earlier. In any event, most of the great changes enumerated have taken place during the present geological period; and man, short-lived as his species has been, has witnessed geological revolutions which have transformed a continent, and rise in magnitude and importance to an equality with any which have visited the surface of our earth in the whole progress of geological cycles.

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* J. Geikie, *Prehistoric Europe*, ch. xiv, xxi and xxii.

It can hardly be doubted that man was present in Europe while yet the continental glacier stretched into central France and northern Italy. We must admit so much, though denying his preglacial advent. We contemplate in our own time the Alpine glaciers as a fine spectacle displayed in the midst of the populous homes of European civilization. We do not shrink from their presence, but most profoundly enjoy their novelty and sublimity ; but could we adequately realize the historical fact that these modern centers of frost and winter are but the vestiges of the reign of a perpetual winter which buried nearly the whole of Europe beneath a mantle of snow and ice, which imposed the silence and solitude of central Greenland for a term of unknown centuries, we might contemplate these Alpine strongholds of frost and desolation rather with the grim satisfaction which one experiences at the fallen fortunes of an implacable enemy. But our predecessors in Central Europe found themselves on the borders of an ice-cap which to them seemed as changeless and eternal as the glacier sheets of the Arctic zone. Generation after generation came and disappeared, and the glaciers almost imperceptibly retreated. European man, accompanied by the reindeer and other northern types of animals, followed the retreating glacier to the shores of Lapland and the slopes of the Alps. In the north his ethnic characteristics have been perpetuated from age to age; and while we wonder over the mystery of the apparition and migrations of our species, the representative of prehistoric man still gazes as of old upon the retiring glacier which now hovers over the Arctic borders of Finland. Farther south, a more enlightened type of the species has absorbed the lingering communities of prehistoric men, and is watching the disappearance of the last vestiges of the great continental glacier vanishing up the slopes of the Alps. The history of man has not gone back to the reign of ice. The reign of ice, like the mammoth, has come down to the age of man. American man has been the witness of similar transformations. He dwelt on the Pacific coast before the epoch of general glaciation. He saw his hunting-grounds buried beneath floods of lava which spread themselves over territory vast enough for half-a-dozen states. His remains lie inclosed in a sarcophagus of lava. He survived the molten inundation which enkindled to luminosity the surface of a planet. He has seen the storms of heaven at work on the erosion of these lava-sheets, and watched the growth of cañons which are a thousand feet deep. All these events, vast and destructive and transforming as they are, have been grasped by the observation of a race which still lives and holds intercourse with ourselves.*

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*The evidences of the Pliocene age of the human remains of California have been gathered together by Professor J. D. Whitney in his work on *The Auriferous Gravels of the Sierra Nevada of California*, 1879. Flint implements occur also in the auriferous gravels where not covered with lava. These gravels contain plants pronounced Pliocene (or partly Miocene) by so good an authority as Lesquereux. Some of the animal species found in the same association are also Pliocene types. The conclusions of Whitney, Winslow, and other discoverers, are undisputed by J. D. Dana, *Manual of Geology*, 3d. ed.. pp. 577–8, and Joseph Leconte, *Elements of Geology*, p. 567. But Mr. James C. Southall says, " *We cannot accept such monstrous conclusions, even if advanced by our*

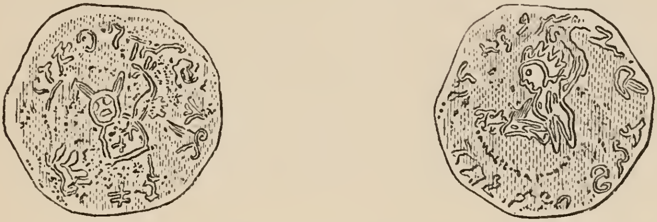
In the Mississippi valley we have some evidence of the existence of man while yet Illinois was flooded by the high waters of Lake Michigan. I had in my possession for some time a copper relic resembling a rude coin, which was taken from an artesian boring at the depth of 114 feet at Lawn Ridge, Marshall county, Illinois. Mr. W. H. Wilmot, then of Lawn Ridge, furnished me, in a letter dated December 4, 1871, the following statement of deposits pierced in the boring:

Soil,	3	feet.
Yellow clay,	17	“
Blue clay,	44	“
Dark vegetable matter,	4	“
Hard purplish clay,	18	“
Bright green clay,	8	“
Mottled clay,	18	“
Soil,	2	“
Depth of coin,	114	“
Yellow clay,	1	“
Sand and clay,		
Water, rising 60 feet.		

In a letter of the 27th of December, written from Chillicothe, Illinois, he stated that the bore was four inches for eighty feet, and three inches for the remainder of the depth. But before one hundred feet had been reached the four-inch portion was "so plastered over as to be itself but three inches in diameter," and hence the "coin" could not have come from any depth less than eighty feet.

most eminent scientific authorities" (*Meth. Quar. Rev.*, April 1881, p. 228). One cannot help wondering what sort of evidence would convince Mr. James C. Southall.

"Three persons saw the 'coin' at the same instant, and each claims it." This so-called coin was about the thickness and size of a silver quarter of a dollar, and was of remarkably uniform thickness. It was approximately round, and seemed to have been cut. Its two faces bore marks as shown in the figure, but they were not stamped as with a die, nor engraved. They *looked* as if etched with acid. The character of the marks was partly unintelligible. On each side, however, was a rude outline of a human figure. One of these held in one hand an object resembling a child, while the other hand was raised as if in the act of striking. This figure wore a head-dress, apparently made of quills. Around the border were undecipherable hieroglyphics. The figure on the opposite side extended only to the waist, and had also one hand upraised. This was furnished with long tufts, like mules' ears. Around the border was another circle of hieroglyphics. On this side, also, was the rude outline of a quadruped. I exhibited this relic to the Geological Section of the American Association, at its meeting at Buffalo in 1876. The general impression seemed to be that its origin could not date from the epoch of the stratum in which



A QUASI-COIN SAID TO HAVE BEEN TAKEN FROM AN ARTESIAN BORING IN MARSHALL COUNTY, ILLINOIS, AT A DEPTH OF ONE HUNDRED AND FOURTEEN FEET. FROM A PHOTOGRAPH FURNISHED BY J. W. MOFFAT.

it is reputed to have been found. One person thought he could detect a rude representation of the signs of the zodiac around the border. Another fancied he could discover numerals, and even dates. No one could even offer any explanation of the object, or the circumstances of its discovery. The figures bear a close resemblance to rude drawings executed on birch bark and rock surfaces by the American Indian. But by what means were they *etched?* And by what means was the uniform thickness of the copper produced?

This object was sent by the owner to the Smithsonian Institution for examination, and Secretary Henry referred it to Mr. William E. Dubois, who presented the result of his investigation to the American Philosophical Society.* Mr. Dubois felt sure that the object had passed through a rolling-mill, and he thought the cut edges gave further evidence of the machine-shop. "All things considered," he said, "I cannot regard this Illinois piece as *ancient*, nor *old* (observing the usual distinction), nor yet *recent*; because the tooth of time is plainly visible." He could suggest nothing to clear up the mystery. Prof. J. P. Lesley thought it might be an astrological amulet. He detected upon it the signs of Pisces and Leo. He read the date 1572. He said "the piece was placed there as a practical joke." He thought it might be Hispano-American or French-American in origin. The suggestion of "a practical joke" is itself something which must be taken as a joke. No person in possession of this interesting object would willingly part with it; least of all would he throw so small an object into a hole where not one chance in a thousand existed that it would ever be seen again by *any* person.

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* W. E. Dubois. *Proceedings Amer. Phil. Soc.*, xii. 224, December 1. 1871. Mr. Jacob W. Moffat, who sent the coin, accompanied it with a statement of formations passed through, which differs slightly from that supplied to me by Mr. W. H. Wilmot. He also makes the depth 125 feet.

If this object does not date from the age of the stratum from which obtained, it can only be a relic of the sixteenth or seventeenth century, buried beneath the alluvium deposited more recently by the Illinois river. The country is a level prairie, and "Peoria Lake" is an expansion of the river ten miles long and a mile and a half broad. It is certainly possible that in such a region deep alluvial deposits may have formed since the visits of the French in the latter part of the seventeenth century. But it is not easy to admit an accumulation of 114 or 125 feet, since such a depth extends too much below the surface of the river. In Whiteside county, 50 miles northwest from Peoria county, about 1851, according to Mr. Moffat, a large copper ring was found 120 feet beneath the surface, as also something which has been compared to a boat-hook. Several other objects have been found at less depths, including stone pipes and pottery, and a spear-shaped hatchet, made of iron. If these are not "ancient," their occurrence at depths of 10, 40, 50 and 120 feet must be explained as I have suggested in reference to the "coin." An instrument of iron is a strong indication of the civilized origin of all.

I do not present these facts as evidence that the Indian roamed over Illinois before the prairie soil was deposited. I do not conclude that these objects may have been lost from Indian canoes at a time when the prairies of Illinois were under water. I think it proper, however, to put them on record, and leave the subject for future elucidation.

Nevertheless, it is well ascertained that the American Indian dwelt in the Mississippi valley before the disappearance of the Mammoth and Mastodon; and it is highly probable that he saw Lake Michigan spreading over Peoria and Marshall and Whiteside counties, and that he paddled his canoe over the regions where these mysterious relics of copper, iron and clay have been discovered. We thus apprehend that the present order of things connects itself by an intelligible continuity with a former set of conditions identified with the origin of a great geological formation; and we feel that we command a unit of measure for a genuine geological æon.

Thus, when we look attentively upon the phenomena occurring in the presence of our species, we find ourselves living in the midst of geological history. Grand geological events no longer recede into the infinite past. Though earlier events reach back over ages uncomputed, the grand revolutions which have made the surface what it is are brought down within our grasp. We feel that we have a hold upon geologic time. We can compass the requisites of stupendous events that transform continents. We feel relief in emerging from the mysteries of the unfathomable past, and setting our feet upon geologic intervals which reveal their limits and their bounds. Man rises to a higher altitude. He grasps a larger thought; he feels his way closer to the Infinite purposes; he is conscious of it, and exults anew in his intelligent existence.

GEOLOGICAL SEASONS.

ACCORDING to the accepted theory of terrestrial refrigeration, the inherent temperature of the earth is continually diminishing. So far as its climates are influenced by inherent temperature, they must continually grow colder. Before the earth began to be incrusted a circulation of its constituent parts must have been active. Loss of heat in the peripheral portions would result in a sinking of those condensed portions toward the center. More highly-heated portions would rise to supply their place. Thus, as in the sea, and in the atmosphere, a circulation would result from the unequal temperatures of different portions.

But after the commencement of incrustation those portions fixed in the crust would no longer enter into the circulation. The superficial portions would remain *continually* exposed to the cooling action of external space. The effect of this would be to depress the superficial temperature below what it would be if all the parts were free to circulate. The crust would become disproportionately cooled, and would continually thicken. The cooling of the interior would be proportionally slackened. The time would arrive when the cooling of the interior would be so much obstructed as to be almost imperceptible. That period seems to be the present. If we may trust the results of mathematical calculation, based on the known conductibility of heat possessed by the rocky materials, the earth's internal heat is so securely imprisoned that it yields but one-fortieth of the actual temperature of the world's surface. This is a calculation of Pouillet. Professor Vogt estimates that if the earth were completely cooled, its surface temperature would be eleven-twelfths as high as at present. These figures show, at least, that the present influence of internal heat upon the climates of the earth is so slight that it may be neglected.

But it is evident that in the earlier periods of crust-formation the earth's internal heat was an important factor in climate. The condition of the atmosphere conspired with the internal heat to raise the mean temperature of the earth's surface. Charged with gaseous impurities, and a superabundance of aqueous vapor, it served as a blanket wrapped around the earth to arrest radiation. The first general principle thus deduced in reference to geological climates is that *they have suffered a secular and continuous depression of temperature.*

But we have much evidence of *grand secular* FLUCTUATIONS *of temperature.* It would involve us in too great detail to enter upon a general discussion of these fluctuaions, but I propose to offer an exposition of the most important, and, as we now understand the subject, the most regular of all the climatic fluctuations which our world has felt.

The northern hemisphere has been visited, at a period geologically modern, by a remarkable depression of temperature. "The Great Ice Age" had barely passed when man first made his advent in Europe. The traces of a geological winter repose everywhere throughout northern America and Europe. The very hills of gravel and clay which so agreeably diversify the general surface of the northern states are records of the last geologic winter, and of the spring-time which followed. The rounded bosses of the rocky outcrops; the grooved, striated and polished rock-surfaces which everywhere underlie the soil and subsoil; the deep-cut gorges of some of the rivers, and the broad erosions of certain lake-basins,—these and other familiar phenomena find their explanation in the activities of a secular winter, which clothed the northern hemisphere as far as the latitude of 36° with a mantle of ice and snow. This ice-period is one of the recognized epochs of geologic history.

Some of the most salient phenomena attributed to the reign of glacier ice are smoothed and striated rock-surfaces, and accumulations of rounded pebbles. Precisely these phenomena have been detected among the rocks of remoter ages of the world's history. More than thirty years ago, the New York geologists called attention to the smoothed surfaces of the Medina Sandstone in the western part of that State. They did not then dare to utter the conjecture that these are glaciated surfaces; though recent opinion strongly inclines in that direction. Foreign geologists have made similar observations in numerous other formations.[*] In the Miocene System, that vast Swiss formation known as the *Molasse*, seems to be but an older bed of glacier pebbles, extremely similar to those accumulated upon the existing surface along the slopes and flanks of the Alps. Mr. Croll, a distinguished Scottish geologist, is of the opinion that most of the shingle formations, through the whole series of rocks, are but ancient glacier accumulations. If so, the evidences of oft-repeated epochs of glaciation are abundant and familiar. The conglomeritic deposits of the Coal Measures are regarded by Croll as of this character, while the coal-beds intervening between the fragmental strata are regarded as the records of interglacial periods. These phenomena of alternating coal-beds and fragmental strata are generally explained on the hypothesis of alternations in the relative levels of land and sea, not necessarily accompanied by great changes of climate. Personally, I do not accept, as yet, Mr. Croll's view. I consider it a plain error to regard all shingle-beds as evidence of glacial action. Pebbles imply attrition,—long continued attrition; but the force of moving water is adequate to the production of beds of pebbles. This is exemplified upon the shores

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[*] Besides the cases cited in the text, we may mention the Cambrian or Laurentian (James Thomson, *British Association*, 1870, 88; A. C. Ramsay, *Swansea Address*, 1880; *Nature*, xxii, 388; A. Geikie, *Nature*, xxii, 402, in northwest part of Scotland);—Lower Silurian (J. Carrick Moore, *Quar. Jour. Geol. Soc.*, Lond., v, 10; *Philosoph. Mag.*, April 1865, 289; Geikie, *Great Ice Age*, 512; Jukes, *Manual of Geol.*, 421; Haughton in McClintock's *Narrative of Arctic Discoveries; Quar. Jour. Geol. Soc.*, xi, 510; A. C. Ramsay, *Swansea Address*, 1880);—Upper Silurian, in Colorado (C. D. Walcott, *Amer. Jour. Sci.*, III, xx, 222, 225);—Devonian (A. C. Ramsay, *Reader*, 12 Aug. 1865; Cumming, *History of Isle of Man*, 86; Selwyn, *Phys. Geog. and Geol. of Victoria*, 1866, 15, 16; Taylor and Etheridge, *Geol. Surv. Victoria*, Quarter-Sheet 13, NE; J. P. Lesley, *2d Geol. Surv. Pa.*, i, 86, Portage Group; C. D. Walcott, *Amer. Jour. Sci.*, III, xx,

222);—PERMIAN (*Amer. Naturalist*, iv, 560; Ramsay, *Quar. Jour. Geol. Soc.*, xi, 197; *Swansea Address;* Sutherland (*Quar. Jour. Geol. Soc.*, xxvi, 514; H. T. Blanford, *ib.* 1875, 519; Daintree, *Geol. Dist. Ballan Victoria*, 1866, xi; C. D. Walcott, *Amer. Jour. Sci.*, III, xx, 222);—TRIASSIC (T. A. Conrad and H. Wurtz, 1869; Jas. D. Dana, *Amer. Jour. Sci.*, III, ix, 315, xvii, 330; Fontaine, *Amer. Jour. Sci.*, III, xvi, 236);—JURASSIC (Fontaine, *loc. cit.*; Judd, *Quar. Jour. Geol. Soc.*, xxix; *Phil. Mag.*, xxix, 290);—between MIDDLE CRETACEOUS and LOWER EOCENE (J. W. Dawson, *Princeton Rev.*, March 1879, 284. Compare also Lyell, *Quar. Jour. Geol. Soc.*, Lond., ii, 280; *Travels in N. America*, 1st Visit, ii, 68; M. Tuomey, *Geol. Ala.*, 116; W. B. Rogers, *Proc. Boston Soc. Nat. Hist.*, xviii, 101 seq. 1875, *Amer. Jour. Sci.*, III, xi, 61);—in the English CRETACEOUS (Godwin Austen, *Quar. Jour. Geol. Soc.*, xiv, 262, xvi, 327; *British Assoc. Rep.* 1857, 62; *Geologist*, 1860, 38);—in the CRETACEOUS of India (A. C. Ramsay, *Swansea Address*);—a cold period at base of *Eocene* (*Nature*, July 10, 1879, 258);—in the FLYSCH of Switzerland (Lyell, *Principles*);—in the MIOCENE (Gastaldi, *Mem. Acad. Sci.*, Turin ii, xx; A. C. Ramsay, *loc. cit.*);—on Croll's extension of the idea to the Coal Measures, see *Climate and Time*, 296-8, and ch. xxvi. Opposed to the doctrine of recurrence of glacial periods, see A. R. Wallace in *Island Life*.

of every river and lake; and still more unequivocally along the ocean's beach.

I am of the opinion, nevertheless, that the northern hemisphere has been repeatedly visited by glaciation. In seeking, therefore, the explanation of the last great ice-age, we must seek a theory which will explain the *succession* of ice-ages. This the older theories failed to accomplish. It was, for instance, suggested long ago as one of the most obvious theoretical expedients, that perhaps the poles and the equator had changed places, bringing tropical climates into regions which are now frigid; or that, at least, the axis of the earth had changed its position, resulting in the location of the north pole somewhere in the north temperate zone. But these hypotheses are opposed by the stability of the movements and conditions of the earth and the solar system. Indeed, changes of the kind mentioned would disturb the harmony of the planetary realm.* Moreover, the displacement of the pole to any extent admissible by possible changes in the figure of the earth, would be an insignificant cause of climatic changes. Mr. G. H. Darwin has shown that to displace the pole 1° 46′, one-twentieth of the surface of the earth must be lifted ten thousand feet. All the physical changes in distribution of the earth's mass which have taken place since the glacial epoch could not have shifted the place of the pole more than six miles. Since Silurian Time no terrestrial changes have occurred which would vary the place of the pole to any perceptible extent. Any change in the position of the pole must accompany a change in the position of the compressed and protuberant regions of the earth. This would change to a great extent the relative location of water and land areas. But the stratified rocks demonstrate that no considerable changes of this kind have taken place since Silurian Time. And finally, the indications of both warmer and colder climates exist on opposite sides of the polar zone; but a change in the position of the pole, while conferring a milder temperature on one side,—say the American Arctic archipelago,—would bring a severer climate to the opposite side,—say in Nova Zembla and Bear Island.

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* Sir W. Thomson, *Brit. Assoc. Rep.*, 1876, pt. ii, p. 11; *Trans. Geol. Soc. Glasgow*, iv, 313; Haughton, *Proc. Roy. Soc.*, xxvi, 51; G. H. Darwin, *Trans. Roy. Soc.*, clxvii, pt. i; I. F. Twisden, *Quar. Jour. Geol. Soc.*, Lond., Feb. 1878; James Croll, *Geological Magazine*, Sept. 1878; G. B. Airy, *Athenæum*, Sept. 22, 1869. *See*, also, Laplace, *Système du Monde*, ed. 1824, p. 392.

Again, it was suggested by Poisson,* and maintained by the elder Agassiz, † that perhaps the earth, in the journey of our system through space, passes occasionally through regions of excessive cold. Others have suggested a diminution of the sun's heat, but restored again in later times. ‡ Both suppositions imply that all parts of the earth's surface suffer a depression of temperature at the same time. This would require that traces of glacier action should exist in tropical as well as temperate regions. The facts, in spite of Agassiz' supposed moraines in the empire of Brazil, do not answer to the expectation.

A theory which enjoys considerable popularity supposes that such distributions of land and water have existed in former times as would change the location of ocean currents to an extent which would revolutionize terrestrial climates.§ That profound climatic characteristics of certain regions are determined by the existing distribution of oceanic currents is a fact which all admit, and which will be further mentioned in another part of this chapter. But to be an adequate cause of the existence of an arctic climate in regions now temperate there must have been a transposition of land and water much more extensive than is allowed by the admitted persistence of the oceanic basins, and the great continental areas. Moreover, it is very difficult to conceive a distribution of land and water which would bring an arctic temperature to New England, New York and Ohio. Most of all, such a theory is not adapted to the explanation of a *succession* of ice-periods.

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* *Théorie math. de la chaleur*, Comptes Rendus, Jan. 30, 1837.

† L. Agassiz, *A Journey in Brazil*, 399, 425.

‡ Lyell, *Prin. Geol.* 128; Sir John Herschel, *Proc. Roy. Astron. Soc.*, No. iii, Jan. 1840.

§ Lyell. *Principles of Geol.*, ch. vii, viii; J. W. Dawson, *Princeton Review*, March 1879; A. R. Wallace, *Island Life; Nature*, xxiii, 124.

Again, *northern elevation* has been cited as a cause adequate to effect the glaciation of the northern hemisphere. Professor Dana, with his usual insight into the symmetry and coördination of things, has directed our attention to the fact that the growth of the continent of North America was, for many ages, toward the southeast and the southwest. When these borders seemed complete the work of development was transferred to the north, and the northern border of the continent was worked out. The development of the land was always effected through a succession of elevations. When considerable elevation had been produced in the northern regions, the climate of the zone felt the effects ; just as southern Austria and northern Italy receive a chill from the Alpine ranges which lie on the north of them, and render the winters of Verona and the Tyrol much severer than those of Berlin and Hamburg. It cannot be denied that northern elevation would materially influence the climate of the temperate zone, but it may be doubted whether the influence would amount to universal glaciation, even if we assume northern elevation throughout all the arctic and sub-arctic regions. It is indeed manifest that the northern regions have undergone great changes of level. All the United States north of the Ohio, and all Canada, have stood at a lower level since the present surface was finished; and there is ground for the belief that just before this subsidence they stood at a higher level than at present. But these oscillations can hardly be conceived an adequate cause of continental glaciation. They do not seem to possess the requisite efficiency; nor have they been timed to suit the relations of causal antecedence to the great phenomenon. It is more probable that the elevation which has taken place is to be regarded as an incident or effect of general glaciation, rather than the cause of it.

Finally, scientists have turned their attention again to the search after an astronomical cause of the great ice-age. That the cause *was* astronomical seems indicated by the proofs of a succession of ice-ages. Astronomical movements describe great cycles. At the end of a certain period the old conditions are reproduced, and the old results are reënacted. The principal ones of these astronomical causes I shall attempt to explain in outline, especially that based on variations in terrestrial eccentricity. The subject, however, will demand the thoughtful attention of the reader. It is a subject not always rationally comprehended, even by geologists who accept the authority for an astronomical origin of ice-periods.

There are three values in connection with the earth's movements, changes in which must affect the earth's climates to some extent. These values are: 1. The inclination of the earth's axis to the plane of the ecliptic; 2. The precession of the equinoxes, or position of the perihelion and aphelion points (apsides) in reference to the equinoctial points; 3. The eccentricity of the earth's orbit. These elements are all changing. They do not, however, change indefinitely in one direction. They pass through a cycle of values. Each has, in the course of ages, its maximum and its minimum. All these astronomical causes were long ago considered, but were successively pronounced inadequate. The search for an adequate astronomical cause was undertaken by Humboldt, Arago, Lyell, Sir John Herschel, and others, but without success. It is not difficult to perceive that the three causes named must produce severally some effect upon the climates of the northern and southern hemispheres respectively; but in each case it has been generally considered unimportant.

As to increased obliquity of the axis, it is obvious that it would render the sun's rays more vertical in the hemisphere turned toward the sun,— that is, the width of the torrid zone would be increased. During summer this increased verticality of the rays would diminish polar glaciation. During winter the sun would be permanently below the horizon ; but that is its condition with the present obliquity. When below the winter horizon, it is immaterial whether one or many degrees below,— the solar influence is simply wanting. Therefore, increased obliquity would not increase glaciation during the winter, though it would diminish glaciation during the summer. The resultant annual effect would be a *diminution of glaciation;* and, correspondingly, diminished obliquity would cause an *increase of glaciation.* This cause would not produce alternating effects in the two polar regions during a succession of secular intervals, but would operate alike in both regions during the whole cycle of changes in the obliquity.

The glaciating action would alternate annually, and only as the seasons alternate.*

As to the precession of the equinoxes, this results in a change in the attitude of the earth's axis when in the apsides. At present, when the earth is in perihelion, the north pole is turned away from the sun, and the northern hemisphere has winter. Suppose that in the course of ages the north pole should become turned *toward* the sun at time of perihelion: then, the obliquity remaining the same, the force of the sun's rays would be increased in the polar regions during the winter by all the amount of the difference in the sun's summer and winter distances from the earth. If, for instance, the sun is now three millions of miles nearer the earth in winter than in summer, in the case supposed the sun would be three millions of miles nearer the earth in summer than in winter. That is, it would be six million miles nearer the earth than at present in summer, and the same amount remoter in winter. But it is in summer that the sun's effects are produced on polar glaciation. The result would therefore be to *diminish* northern glaciation. During winter, as the sun is permanently below the horizon, or near the horizon, it is comparatively immaterial whether three millions of miles more remote or not. Half a cycle in the precession of the equinoxes would therefore diminish northern glaciation and correspondingly increase southern glaciation. The complete cycle of precession is about 21,000 years; hence from this cause we should have in the northern hemisphere a secular winter every 21,000 years, followed, after 10,500 years, by a secular summer. The southern hemisphere would have secular winters and summers alternating with those of the northern hemisphere.[*]

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* See a paper by James Croll in *Geological Magazine*, London, Sept. 1878.

Whatever the climatic effect of this astronomical cause, it is now generally regarded as insufficient. Mr. Croll indeed pronounces its efficiency null.[†]

Lastly, let us consider the effects of increased eccentricity of the earth's orbit on the climates of the northern hemisphere,—understanding increased eccentricity signifies an elongation of the earth's orbit, so as to bring the perihelion point nearer the sun, and remove the aphelion point to a greater distance. This subject was investigated by Sir John Herschel,[‡] and after him by Arago and Humboldt; but their conclusion showed that neither increase nor diminution of eccentricity could directly influence, to any material extent, the amount of heat received by the two hemispheres respectively in the course of a year; or so disturb the annual distribution over either hemisphere as to result in a permanent and general glaciation. This results from the fact that just in proportion as the earth's perihelion distance from the sun is diminished, the earth's orbital velocity in that part of its orbit is accelerated, and thus the perihelion effect upon climate is shortened in duration; and just as the aphelion distance is increased the earth's aphelion velocity is retarded, and the diminished solar intensity is continued enough longer to compensate for its feebleness. M. Adhémar subsequently subjected the question to a more thorough investigation, and announced that increased eccentricity *concurring with the precession of the equinoxes* would so modify the climate of the northern hemisphere as to produce, once in 21,000 years, the geological winter to which I before referred. Nevertheless, the general opinion of physicists has been opposed to Adhémar's conclusion in reference to the amount of the modification.

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[*] Adhémar, *Revolutions de la mer*, 2d. ed., 1860; Le Hon. *Periodicité des Grandes Déluges*, 1858; A. R. Wallace, *Island Life*. Mr. J. J. Murphy maintains that the occurrence of the summer solstice in perihelion would tend to *increase* northern glaciation (*Quar. Jour. Geol. Soc.*, xxv, 350).

[†] Croll, *Climate and Time*, 83; *Phil. Mag.*, Sept. 1869. See, also, Arago, *Edinb. New Phil. Jour.*, vi, 1834.

[‡] Sir J. Herschel, *Geological Transactions*, 1832; *Treatise on Astronomy*, § 315; *Outlines of Astronomy*, § 368; Arago, *Annuaire du Bureau des Longitudes*, 1834, p. 199; *Edinb. New Phil. Jour.*, April 1834, p. 244; Humboldt, *Cosmos*, iv, 459, Bohn's ed.; *Phys. Descrip. Heavens*, 336.

The subject has been more recently taken up by Mr. Croll, of Glasgow; and he has shown by an ingenious course of reasoning that though the *direct* effect of an increased ellipticity in the earth's orbit might be inconsiderable, still the effect produced would so modify the oceanic currents as to greatly increase the precipitation of snow in the northern hemisphere, and diminish the amount of snow and ice in the southern.*

The calculations of astronomers have shown that when the eccentricity is at a maximum the earth will be 14,212,700 miles farther from the sun in aphelion than in perihelion. As the periods of high eccentricity continue from 50,000 to 75,000 years, the precession of the equinoxes, which completes its cycle in about 21,000 years, will bring the winter solstice of either hemisphere to coincide

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*James Croll, *Climate and Time*. See a brief statement of the theory by Mr. Croll in the *Geological Magazine*, Sept. 1878, extracted in *Amer. Jour. Sci.*, III, xvi, 389, and a fuller statement by the present writer in *International Review*, July-August 1876. See criticisms of Croll's work, by S. Newcomb, *Amer. Jour. Sci.*, III, xi, 263; J. J. Murphy, *Quar. Jour. Geol. Soc.*, xxv, 350, 1869, abstract *Amer. Jour. Sci.*, II, xlix, 115-18; Ch. Martins, *Revue des Deux Mondes*, 1867; W. J. McGee, *Popular Science Monthly*, xvi, 810; C. B. Warring, *Penn Monthly*, 1880. Further on this subject the reader may consult Le Hon, *L'Homme Fossile*, pt. ii; Col. Drayson, *Phil. Mag.*, 1871, abstracted in *Amer. Jour. Sci.*, III, ii, 304; Sir W. Thomson, *Geological Climate*, Trans. Geol. Soc., Glasgow, February 1877, vol. v, pt. ii; James Geikie, *Prehistoric Europe*, 1880; G. Pilar, *Ueber die Ursache der Eiszeiten*.

with the earth's aphelion once or more during the continuance of a period of high eccentricity. At the present time the winter solstice of the northern hemisphere occurs in perihelion. When brought to occur in aphelion during a cycle of extreme eccentricity, the earth would be 8,641,870 miles farther from the sun in winter than at present. This difference would cause the sun's intensity to be one-fifth less during winter than at present. It is true that it would also be one-fifth greater during summer; and thus the annual constant of the solar heat would not be diminished. To speak more precisely, it would actually be increased by one three-hundredth part, since the annual amount of heat is inversely proportional to the minor axis of the earth's orbit. It is also true that while the sun's intensity during the northern winter would be diminished one-fifth, the duration of the season would be prolonged forty-four days beyond its present length, and would be thirty-six days greater than the duration of the summer. Thus not only would the winter heat be diminished, but the diminution would be prolonged. This would, indeed, secure the same absolute aggregate of winter heat as at present; and this conclusion is as far as Mr. Croll's predecessors went in the investigation of this problem. The total amount of winter heat being the same, its total effect, they argued, would be the same. Mr. Croll's merit consists in taking into account the effect of a diminished daily intensity, and of the extension of this through a longer period. In all climatic investigations, as is shown in another chapter of this work, the means of short periods are quite as important as the means for long periods. It is the extreme cold of winter which conditions the growth of vegetation,

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The answer to the first question involves the determination of the physical causes of ocean currents. Since the appearance of Maury's *Physical Geography of the Sea* it has been generally conceded that the circulation of the waters is simply an interchange between the arctic and inter-tropical regions, resulting from a difference in densities. Mr. Croll, however, has pointedly demonstrated that this hypothesis is untenable, and that Maury's own reasonings result in mutual nullification. Increased density (resulting from greater saltness) in intertropical regions, caused by excess of evaporation, would equalize diminished density (rarefaction) caused by excess of heat. Hence no resultant diminished density in the intertropical regions exists to initiate a flow of denser (colder) water from the arctic regions; and the circulation, which certainly is a fact, cannot be explained by the theory of Lieutenant Maury.

Dr. W. B. Carpenter has more recently propounded, and defended with characteristic positiveness and persistence, a theory somewhat different from Maury's. He appeals chiefly to the expansive effect of the excessive heat of the intertropical regions. The expansion of the intertropical waters creates, as he maintains, a sort of protuberance. The waters, seeking always a statical equilibrium, would flow, superficially, down a gentle slope, from the equator toward the poles; while this flow would be compensated by an undercurrent setting from the polar to the intertropical regions. This much vaunted theory seems to me inadequate, untenable and contradictory. 1. It takes no account of the influence of excessive evaporation in the intertropical regions, which, in a general way, may be assumed to reduce the volume of the water quite as much as expansion would increase it; so that the equatorial protuberance of the waters is quite imaginary. 2. The directions of the superficial and deep currents are not such as would result from a normal circulation like that in the atmosphere. That is, the out-going currents, modified by terrestrial rotation, and neglecting the influence of continental barriers, should be *toward* the northeast and southeast (with an eastward direction immediately over the equator) *in the upper portion of the film;* and the returning currents should be *from* the northeast and southeast (with a westward direction over the equator) *in the lower portion of the film.* Observation shows, however, that the *upper* portion of the watery film is characterized by movements coincident with those of the *lower* portion of the atmospheric film. The two sets of motions cannot, therefore, be traced separately to the same physical cause. 3. The amount of expansion of the intertropical waters would not be adequate to cause a tendency to flow toward the poles. As Mr. Croll has shown, the difference between the equatorial and polar temperatures of the waters would disturb the equilibrium by only the trifling amount of four and a half feet. Distribute this between the equator and the poles, and the descent would not be sufficient to overcome the viscidity of the water. 4. Should any intertropical protuberance exist as a result of the cause assigned, and should it produce a flow toward the poles, the process would only continue until the protuberance should be removed. No cause can be assigned why the deeper, colder and heavier water should rise into the lighter, and reproduce the protuberance. That is, the water, however rarefied, would reach a state of statical equilibrium, and remain so thereafter. It may fairly be inferred, therefore, from the four considerations just presented, that *the circulation of the waters of the sea is not caused directly, as the circulation in the atmosphere is caused.* We might, of course, recognize the existence of a necessary tendency to a circulation of the waters, identical with that of the air, and proceeding from the same cause. But the actual circulation is one which demonstrates the existence of some influence which more than countervails such a primary tendency, and establishes identical, instead of contrary, movements in the films of water and air which are in contact with each other. On physical principles, however, it does not appear that a circulation would be established in a body of water through the simple application of a warming influence at the upper surface.

This coincidence between oceanic currents and prevailing winds is, indeed, so complete as to suggest a causal relation between the atmospheric and oceanic movements. The suggestion is further sanctioned by all we know of the power of winds to move the surface of the ocean's waters. Who has witnessed a storm at sea without being convinced of this power? Within a few years an easterly wind has so piled up the waters of the Gulf of Mexico along its western border as to inundate and devastate entire cities and villages. We seem quite justified, especially in view of the demonstrated inadequacy of the causes urged by Maury and Carpenter, in pronouncing the *system of prevailing winds the physical cause of the system of currents.*

Now, it is apparent, in the next place, that the force of the winds — the "trades," for example — is determined by the difference of temperature between the polar and the equatorial regions. If, furthermore, the cold of the arctic regions equals that of the antarctic, the northern trades will meet the southern trades at the equator, and the equatorial current will flow westward *midway between the tropics.* If, as at present, the cold of the southern hemisphere is in excess, the southeast trades will possess greatest force, and pass to the north of the equator, determining the position of the equatorial current somewhat nearer to the northern tropic than to the southern. If, on the contrary, the cold of the northern hemisphere should, as we have supposed, under the influence of high eccentricity, become considerably in excess of the cold of the southern hemisphere, the equatorial current would be shifted to some latitude south of the equator.

The configuration of the continents is such that the position of the equatorial current exerts a most important influence upon the direction of its trend out of the torrid zone. At the present time, for instance, with this current a few degrees north of the equator, the larger portion of it is deflected northward by the shore of South America; and passing through the Caribbean Sea and the Gulf of Mexico, issues as the Gulf Stream, which diagonally crosses the North Atlantic, and impinges upon the shores of Western Europe. Its movement across the Atlantic is aided, and we may well believe is caused, by the prevailing westerly winds of the North Temperate Zone. With the equatorial current flowing as far south of the equator as would be implied in the extension of the persistent snow-cap of the northern hemisphere, the contact of the current with the coast of South America would take place to the south of Cape St. Roque, and its deflection would be into the South Atlantic. Whatever influence the Gulf Stream at present exerts upon the climate of the northern hemisphere would, on the hypothesis of an extended northern snow-cap, be completely withdrawn.

To what does this influence amount? Mr. Croll has shown that about one-fifth of all the heat possessed by the waters of the North Atlantic, within the limits of the North Temperate Zone, is derived from the Gulf Stream. According to Dove, the mean temperature of London is 10° above the normal temperature of that parallel of latitude. This excess has been justly attributed to the influence of the Gulf Stream. But this by no means measures the absolute influence of the Gulf Stream. This current, with the other outgoing currents from the tropical zone, raises the general temperature of the North Temperate Zone, so that the normal temperature of the London parallel is 30° above the temperature which *would be* normal were all the ocean currents arrested. The absolute influence of the Gulf Stream upon the climate of London is represented, therefore, by 30°+10°=40°. A depression of the mean temperature of London to this extent would constitute a serious modification of its climate.

Now, in accordance with the theory here under consideration, the reduction of London temperature which must result from the arrest of the Gulf Stream would take place precisely when the intensity of the solar radiation would be diminished one-fifth, and the winter season prolonged 36 days. Let these three causes of a climatic chill concur, and it becomes easy to admit that the wintry precipitation of Great Britain and all northern Europe must be in the form of snow, and in such amounts as to outlast, like the living Alpine glaciers, the dissolving action of the intensest summer sun. We seem, therefore, to have discovered, in high eccentricity, a cosmical cause capable of putting in action such terrestrial agencies as must necessarily lead to the extensive glaciation of the northern and southern hemispheres alternately.

This conclusion affords us a glimpse into the possible future of the course of civilization. When, in some remote coming age, the softening influence of the Gulf Stream shall be transferred from the western shores of Europe to the eastern shores of Patagonia, the climate of Great Britain will return to the condition determined by the fundamental astronomical factors of climate. What this condition is may be understood from the present climates of other regions in the same zones of latitude, and not influenced by oceanic currents,—Athabasca, Labrador, Tobolsk in Siberia, and Central Kamtchatka. Then the Falkland Islands and Tierra del Fuego will acquire the present climate of Great Britain. London will have dwindled to a whaling station in the icy seas of the far north. Another London will have sprung up on the genial shores of Falkland; another Paris will have been built on the Straits of Magellan, and all the centers of human civilization and industrial activity will have been transferred to the southern hemisphere. The lands of the north will have been borne down by a load of arctic ice, beneath the cold waters of the North Atlantic, and the now submerged continents of the south will have been disburdened of their secular glaciers, so as to rise up and offer a new theater for the activities and further progress of the human species.

The present theory of glacial periods affords us a clew to the solution of the difficult problem of geological time. The epochs of high eccentricity are susceptible of determination by mathematical analysis.* The results of calculation show that a period of high eccentricity terminated about 80,000 years ago, and another period about 720,000 years ago. To which of these shall we refer the Glacial Period of Post-Tertiary time? Certain geologists, impressed by the vastness of geological intervals, would decide promptly in favor of the remoter epoch. But, as we have stratigraphical evidence of the occurrence of an earlier glacial period in Miocene time, the date of this would be removed back to the next preceding period of high eccentricity, 2,500,000 years ago. The admission of such an interval since Miocene time would set back the commencement of sedimentation beyond 100,000,000 years, which, as Sir William Thomson has demonstrated, is the largest interval which can be admitted, according to the laws of cooling, since the commencement of terrestrial incrustation.†

We have then to examine whether an interval of 80,000 years is sufficient for the whole amount of denudation which the continents have suffered since the Glacial Period. An ingenious investigation, instituted by Mr. Croll, shows that the actual denudation is not less than one foot in six thousand years. If we assume the Glacial

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* See especially Stockwell, *Smithsonian Contributions to Knowledge*, xviii; Croll, *Climate and Time*. ch. iv, xix; R. W. McFarland, *Amer. Jour. Sci.*, III, xi, 456.

† The interval since the last decline of continental glaciers, judging from the comparative amount of sedimentation and other geological results, is not over four tenths of one per cent of the whole time since the beginning of incrustation. Authorities differ widely as to the possible length of that time. Professor Newcomb says the total mass of the sun would cool from its present condition to a body as dense as the earth in twelve million years; and that not over ten million years can have elapsed since the heat of the sun was too great to permit water to exist on our planet. With such views it is improbable that Post Tertiary time amounts to more than 61,000 years, or Post Glacial time to more than 30,000 years.

Period to have terminated 720,000 years ago, the denudation in the intervening time must have amounted to 120 feet, which Mr. Croll thinks would imply the removal of all the detrital deposits of the continental glacier. They have not been thus removed, and consequently 720,000 years is too high a figure. If we assume the Glacial Period to have terminated 80,000 years ago, then 13 feet of rock, or 18 feet of drift, must have been removed from the whole face of the continents; and this, according to good authority, is all that has been done. My own judgment of the evidences is that the rate of denudation is greater than has been assumed; and hence I must consider 80,000 years as abundantly adequate for all the post-glacial erosions. This opinion is confirmed by what we have observed of changes in progress before our eyes; in the recession of glaciers, the transportation of soils, the filling of lakes, and the shifting of river-channels, as well as in the disappearing relics of the continental glaciers, hidden in mountain gulches and rocky crevices, or slowly wasting beneath accumulations of common drift.*

I stated that northern oscillations of level are to be regarded rather as consequences than as causes of northern glaciation; and I have alluded already to a submergence of northern lands as an accompaniment of the next general glaciation of the north temperate zone. Let us return to this for a moment. The formation of an extensive ice-cap about either pole, and its relative diminution about the other, must have a tendency to displace the earth's center of gravity toward the loaded pole. Beneath a film of water free to adjust itself as the ocean

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*The author has more fully considered this subject in *Preadamites*, ch. xxvii.

is, with reference to the preservation of the old center of gravity, the displacement would not actually occur. The protruding polar ice would press the unyielding core of the earth through the spheroidal shell of water sufficiently to conserve the position of the center of gravity. But the incidental result would be a relative subsidence of the loaded pole and an emergence of the opposite one. These deductions are in perfect accordance with observed geological facts. These show that a general northern subsidence was associated with the glaciation of the northern hemisphere. The deduction is also in accord with the present condition of the south polar regions. If the northern hemisphere is at present in the enjoyment of its geological summer, the southern must be in the midst of its geological winter. The southern hemisphere must be now in a state of glaciation; and, in accordance with what I have just said of the displacement of the earth's center of gravity by the accumulated ice, the south polar regions must be many feet lower, relatively to the sea-level, than they were during the southern geological summer; that is, the lands of the southern hemisphere must be extensively submerged. That they are actually submerged is a fact of observation. Commander Wilkes, of the United States Exploring Expedition, coasted seventeen hundred miles along a barrier of ice-cliffs lying under the Antarctic circle. These cliffs must rest on solid land; and some thousands of years hence, when the Antarctic summer returns, the burden of ice may be removed; those submerged lands may rise again above the surface; the southern extremity of South America may extend itself to the Falkland and other contiguous islands; Wilkes' Land, Victoria Land and Graham's Land may become as accessible as Alaska; a new continental connection may stretch across the South Pacific. On the other hand, the American Arctic archipelago may become submerged; the sea may cover the larger part of British America and Siberia, and the civilization which for four thousand years has distinguished the northern hemisphere may be transferred to the southern.

Another outcome of this cosmical theory of terrestrial glaciation possesses, at least, a scientific interest. As the periods of high eccentricity must continue from 50,000 to 75,000 years, the coincidence of the winter solstice with the aphelion must occur at two or three epochs during a term of high eccentricity; and these epochs would alternate with coincidences between winter solstice and perihelion. That is, two or three epochs of intense glaciation must occur during one term of high eccentricity, separated by interglacial epochs of milder temperature. Phenomena precisely answering to this deduction are believed to present themselves in connection with the deposits of the Glacial Period of geology. To say no more, geologists now generally recognize at least one interglacial period during the progress of the last great ice-age.

THE CLIMATE OF THE LAKE REGION.*

CLIMATE is constituted chiefly of temperature, humidity and winds. Under average conditions, temperature is by far the most important of the three. So far as our bodily organs are concerned, it is chiefly the sensible temperature which is affected by changes in the humidity and movements of the atmosphere. In warm weather an increase of humidity is equivalent to an increase of heat; in cold weather it produces the sensible effects of a diminution of heat. The extremes of temperature are, consequently, most felt in humid climates.

Winds, by promoting evaporation, and a consequent drying of the soil, though they tend primarily to the production of humidity, result speedily in a partial exhaustion of the sources of moisture, and a consequent aridity of the atmosphere, which diminishes the sensible effects of temperature. Their *direct* influence upon sensible temperature is far greater. A movement of the atmosphere is always cooling, even though the temperature be nearly that of the blood. This effect is produced largely by the promotion of evaporation from the skin. In cold weather it is due partly to the penetration of our clothing by portions of air impelled through every pore by the pressure of other portions behind them. At all temperatures winds also exert an *actual* cooling influence by the promotion of evaporation, during which large quantities of heat pass into the "latent" state. In treating, consequently, of the climate of the Lake Region it is the temperature element to which we invite especial attention.

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* Based, in part, by permission, on an article contributed to *Harper's Magazine.*

The climate of the Lake Region presents some peculiarities of extreme interest. They originate in the presence of vast bodies of water in the midst of a wide continental area. The Great Lakes of the interior have long been recognized as exerting a certain climatic influence. Allusion has been made to this in the meteorological papers of the late Secretary Henry, of the Smithsonian Institution, by Mr. Loren Blodget, in his great work on the Climatology of the United States, and at an earlier period by Humboldt and others. This knowledge, however, has heretofore been little more than a deductive conclusion or presumption. Mr. Blodget's isothermal lines march across the peninsula of Michigan, and across the entire lake region, as if the whole surface were one unbroken land area. Still cruder is the isothermal chart of the United States, "as determined by the Smithsonian Institution,"* and published a year or two earlier than Blodget's work. It will be understood, as a necessary inference, that the charts based on the army observations,† as well as all previous attempts at isothermal charts, fail totally to detect the local climatic influence which, as we now know, bends the isothermal lines of the Michigan peninsula in the most extraordinary manner. Before the investigations made by the present writer, almost no exact comparative observations had been made in such form as to reveal the great influence of the lakes. Dr. Jared P. Kirtland, of Cleveland, had published a note on the influence of Lake Erie; but, aside from the phenomena connected with the growth of vegetation, and the presence of southern birds and insects, he recorded no exact data beyond a few single observations.[*] He states that killing autumnal frosts are about a month later on the lake shore than in the interior, and that, in a case of extreme cold, the thermometer marked about six degrees higher at Cleveland than at points some miles back from the lake. Until within a few years observations did not exist from which the influence of the lakes could be deduced in any numerical form. But under the Smithsonian system continued for many years, and more lately adopted, to some extent, by the Agricultural Bureau, an aggregate of data has resulted which, combined with the observations of the United States Lake Survey, and with meteorological tables in the possession of private parties, has enabled the writer for the first time to eliminate, and express in a series of isothermal curves, the proper influence of the Great Lakes — especially Lake Michigan — in modifying the climate of each season, of the whole year, and of each month in the year. It is believed the general purport of the tables and charts can be made intelligible to the general reader.[†]

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* *Patent Office Report for 1856.* Agriculture, Plate iv.

† *Army Meterological Register*, 1855. It is impossible to overestimate our obligations to the army officers who planned and executed the extended series of observations taken at the military posts of the United States.

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[*] J. P. Kirtland, *Amer. Jour. Sci.*, II. xiii, 215 and 294.

[†] Memoirs on this subject by the present writer may be found as follows: "*The Grand Traverse Region: a report on the Geological and Industrial Resources of the Counties of Antrim, Grand Traverse, Benzie and Leelanaw in the Lower Peninsula of Michigan*, 8vo, 82 pp. with *Map* and an *Appendix* of 16 pp. on Palæontology, 1866; *The Fruit-bearing Belt of Michigan*, Proc. Amer. Association, 1866, pp. 84-89; *The Isothermals of the Lake Region*, Proc. Amer. Assoc., 1870, pp. 106—117: *Report on the Progress of the State Geological Survey of Michigan*, Lansing. 1871; Walling's Atlas of Michigan. 1873; *Michigan: being Condensed Popular Sketches of the Topography, Climate and Geology of the State*, 8vo, 121 pp. 1873; *Zeitschrift der österreichischen Gesellschaft für Meteorologie*, vol. vii, p. 351 and viii, p. 40. February 1, 1873; *The Climate of Mich-*

The temperature of the earth's surface, and all those incidents of climate conditioned by temperature, are determined by the solar energy. It is indeed true that the earth's interior exists in a highly-heated condition, and we must probably admit that parts of the central portion still remain in a molten state. In any event, the interior can only be in a solid state as the consequence of pressure sufficient to counteract the liquefying tendency of intense heat. But notwithstanding the intensity of the internal heat, very exact experiments seem to have proved that the central heat is escaping to the surface with such extreme slowness that the superficial temperature is affected to a barely appreciable extent from this cause.

The total amount of heat received by the earth from the sun varies with the distance between the two bodies. As the form of the earth's orbit is an ellipse instead of a circle, while the sun occupies one of the centers or foci, the earth approaches considerably nearer the sun in one extremity of its orbit than in the other. The difference in the distances is about three millions of miles, while the mean distance is about ninety-two and a third millions of miles. In consequence of the diminished distance of the earth from the sun at perihelion, the intensity of the sun's rays is three and one-third per cent greater than the mean intensity. At aphelion his intensity is three and one-third per cent less than the mean.

It is an interesting fact, and one of momentous consequence to our race, that the annual period of greatest intensity occurs during the *winter* of the northern hemis-

igan, in Annual Report of the State Horticultural Society for 1880. See, also, S. B. McCracken; *The State of Michigan, embracing sketches of its History, Position, Resources and Industries*, 1876, 8vo, 136 pp.; and Dr. H. F. Lyster, *Sixth Annual Report of the Secretary of the State Board of Health of the State of Michigan*, pp. 167-250.

phere, and the period of least intensity during our summer. The effect must be to mitigate the extremes of both seasons. As the southern hemisphere experiences the refrigerating effect of diminished distance during its winter, the limits of the uncultivable and uninhabitable zone would be removed considerably farther from the south pole than they are from the north pole, were it not for the fact that the larger proportion of watery surface in the southern hemisphere prevents that hemisphere from accumulating or losing heat as rapidly as the broad continental surfaces of the northern hemisphere. In the course of some thousands of years, however, all this will be reversed.* The effects of such a cosmic change of climate upon the populations of the northern hemisphere must be literally of a revolutionary character,—like that of which a faint reminiscence is retained in the Zend Avesta.

The foregoing considerations concern only the aggregate amount of heat and light received by the earth as a whole. The actual heating and illuminating effects of the sun at any particular spot on the earth's surface vary also, with the angle at which the solar rays strike the spot. This angle varies with the seasons and the hours of the day. From whatever cause a variation in the altitude of the sun is produced, his heating power is always proportional to the perpendicular let-fall from the position of the sun upon the horizon.

Every one knows that the mid-day sun is less vertical in winter than in summer. There is always some latitude, however, at which the mid-day sun is exactly in the zenith. About the 21st of June it is the tropic of Cancer. From this time the sun recedes toward the south, becoming vertical at the equator about the 21st of September, and reaching the tropic of Capricorn about the 21st of December; pouring his vertical rays upon that tropic at about the time when, from our increased proximity to the sun, they possess the greatest inherent intensity. The equator, being the half-way station in the annual journey of the sun from tropic to tropic and back again, receives a greater average verticality of the solar rays than any other parallel. The mean heat produced at the equator by the sun's influence has been ascertained to be about 82°. The mean temperature at any parallel of latitude north or south of the equator is proportional to the diameter of that parallel; or, in the language of science, it is proportional to the co-sine of the latitude. From this law we calculate that the normal annual temperature of New York is 62°.51; that of Chicago is 61°.5; that of Mackinac is 57°.12.

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* See "Geological Seasons."

The altitude of the sun varies also with the hour of the day, and the solar intensity varies accordingly. From sunrise to mid-day the intensity continually increases, and from mid-day to sunset it diminishes. The total heat of the day is the sum of all the intensities from instant to instant between sunrise and sunset. The value of the total depends both on the magnitude and, as we may express it, the number of the intensities during the day. In other words, the total amount of heat received during a day is determined both by the intensity of the solar rays and the length of the day. At the equator the length of the day is always twelve hours. In consequence of this, the total daily heat received at the equator is less than the total daily heat received at places in the northern hemisphere, where, though the solar intensity is less, the day is much longer. On the 15th of June, for instance, the diurnal intensity at the equator is 72°, while in the latitude of forty degrees it is 90°.1. At the north pole, where the day may be regarded as twenty-four hours long, the daily intensity on the 15th of June is 97°.6. The amount of heat received at the pole is in excess of that received at a point on the equator from the 10th of May to the 3d of August,—a period of eighty-five days. On the parallel of forty degrees the excess of diurnal heat extends from the 24th of April to the 20th of August,—an interval of one hundred and eighteen days.

These contrasts, however, it must be remarked, apply only to the upper stratum of the atmosphere.

The sun's intensity at the earth's surface is materially diminished by atmospheric absorption, and this effect is peculiarly experienced by the slanting rays of the polar regions.

So far we have considered the temperature of a locality only in its relation to astronomical conditions. The normal astronomical temperature is almost always disguised by numerous perturbating influences of a local character. The influence of winds and moisture upon the sensible, and also upon the actual, temperature has already been mentioned. There are other local conditions, however, which exert a permanent and more important influence. The most efficient of these are altitude above the sea-level and proximity to great bodies of water. It is well understood that the temperature falls as we ascend above the level of the ocean. The rate of diminution of temperature varies with the hour of the day, the season and the latitude. In temperate latitudes it may be taken at one degree for every 333 feet of ascent. Lake Superior, being 627 feet higher than the Atlantic, must experience a diminution of temperature of nearly two degrees. At the level of Lake Michigan, whose altitude is 587 feet, the temperature should be one and three-fourths degrees less than at the sea-level. As the mean height of the lower peninsula of Michigan is about 750 feet above the sea-level, its mean temperature is diminished two and one-fourth degrees.

Of all local influences affecting climate none are more efficient or more interesting to study than the relations of a locality to extensive continental areas, to oceanic currents, and to large bodies of water. The ocean is the great equalizer of temperatures. By a providential arrangement, watery surfaces absorb and radiate solar heat less rapidly than land surfaces. Continental areas, consequently, become more heated in summer and in tropical latitudes, and more refrigerated in winter and in arctic latitudes, than the oceanic areas in the same seasons and latitudes. These unequal temperatures affect unequally the superincumbent masses of atmospheric air. From this source arise movements of the air, which, combined with the rotation of the earth on its axis, generate trade-winds and the other prevailing winds of different regions. Prevailing winds moving over the surface of the sea set its waters in motion. Thus ocean currents are established which, reflected northward and southward by continental shores, serve to transfer tropical warmth to the polar regions and polar cold to the tropical regions. From these causes it happens that in tropical latitudes the open sea is cooler than the land, while in polar latitudes it is warmer than the land. In the temperate zones the temperature of the sea exceeds that of the land in winter and falls below it in summer. Winds blowing from the sea upon the land carry with them somewhat of the temperature of the water. At Boston, consequently, or at New York, or Savannah, a sea-breeze exerts a cooling influence in summer and a warming one in winter.

The amount of equalizing influence exerted by the ocean must obviously depend on the proximity of the water and the relative amount of wind blowing from the water over the land. The interior of large land areas, like North America, Europe or Australia, must preserve nearly the temperatures due to the common astronomical conditions, and the capacity of the land alone to absorb and radiate solar heat. Hence the British Islands have a more equable climate than Russia. The winters of New York are less severe than those of Saint Louis, though the latter is nearly two degrees farther south; and the summers also are less excessive. But the direction of the prevailing wind is a circumstance of the utmost importance. A location by the ocean's shore would experience extremely little of the equalizing influence of water if the movement of the atmosphere were always from the land. Now, it results from the rotation of the earth that the prevailing winds in the temperate zone are westerly. Those localities, therefore, which lie upon the eastern shores of the oceans experience more the ameliorating influence of situation than those upon western shores. The climate of Western Europe is accordingly less subject to extremes than that of Eastern North America. Western Europe is more equable than Central and Eastern Europe; as our Pacific shores possess a less rigorous climate than our Atlantic States in the same latitudes.

Were we to run a line westward from New York through all the places which have the same winter temperature as that city, we should find that in receding from the coast it would gradually deflect southward. Toward the center of the continent the amount of the deflection would be considerable; but in approaching the Pacific coast we should observe a very remarkable deflection toward the north. In the elevated regions of the Allegheny and Rocky mountains would, indeed, interpose the disturbing effects of increased altitude, so that our isothermal line would be abruptly deflected southward in passing both these mountainous belts, but would turn northward again to its normal position after passing them. The winter isothermal of 30° passes through New Haven in latitude 41° 18′. In Kansas this isothermal is as far south as Fort Riley (39°), whence it bends northward to beyond the latitude of Fort Laramie (42° 40′). Experiencing there a sudden southward flexure to Santa Fé (35° 30′) in crossing the Rocky Mountains, it then resumes its northward trend upon the Pacific slope, and reaches the Pacific shore only within the limits of Alaska.

The climatic influences of vast bodies of salt water, like the Atlantic and Pacific oceans, have long been understood. The effect of small inland bodies of fresh water in averting early autumnal frosts has also been generally remarked. But, as before intimated, meteorologists do not seem to have observed till recently that great lakes, like Lake Michigan and Lake Superior, exert an influence in deflecting the isothermal lines which is quite comparable with that exerted by the great oceans themselves.

These lakes, in truth, are no inconsiderable representatives of the ocean. Lake Superior is 460 miles long and

160 broad, with a mean depth of 988 feet. It has a superficial area of 32,000 square miles. The State of Massachusetts might stretch herself out at full length and bathe in its waters. Even then there would be room enough for Rhode Island at her feet and Connecticut at her head, with Vermont stretched along her right and New Hampshire on her left. You may take all New England, excepting Maine, and hide it bodily beneath the waters of this single lake. Lake Michigan is 360 miles long, 108 broad, with a mean depth of 900 feet, and a superficial area of 20,000 square miles. It contains 18½ millions of cubic yards of water, or, in other words, 3,400 cubic miles. You could sink in this lake the three states of New Jersey, Delaware and Maryland. Lake Huron, with a length of 270 miles, and a breadth equal to that of Lake Superior, has a mean depth of 300 feet, a superficial extent equal to that of Lake Michigan, and would swallow up the whole kingdom of Denmark, including the Prussianized duchies.

You may embark on a sea-worthy steamer at Chicago, and travel for thirty hours without a sight of land; and, after having passed the Straits of Mackinac, and entered Lake Superior, you may steam for two days more without reaching Superior City or Duluth. The voyage from Buffalo to Chicago around the lakes is a thousand miles; from Buffalo to Duluth is eleven hundred miles, or three-fifths the distance from Newfoundland to Ireland.

The majesty of the tempest is little less on the lakes than on the Atlantic, and the low, perpetual moan of the breaking waves along the beach transports the imaginative listener to Long Branch or Nahant. During a summer day they breathe, like the ocean, a cooling atmosphere on every shore, while at night the direction of the breeze is frequently reversed. These are our interior land and sea-breezes. To complete the analogy, our great inland seas exhibit the fluctuations of a diminutive but genuine lunar tide.

It is impossible that such enormous masses of water should be materially elevated above the mean temperature of the year by three months of summer weather, or depressed materially below it by three months of winter. The land surfaces in the same latitudes attain far greater extremes of cold and heat than the lakes. Two reasons exist for this: first, watery surfaces absorb and radiate more slowly; and secondly, the continued stirring of the waters by the winds mixes the surface temperature through a depth of several hundred feet, while on the land the entire effect is confined to a superficial zone of about seventy to ninety feet. The normal mean annual temperature of the land in the neighborhood of Milwaukee is 44°, and this should be about the mean temperature of the water of Lake Michigan. In summer the Milwaukee mean rises to 67°, while in winter it sinks to 22°. The water of the lake, meanwhile, rises in summer only to 46°, and sinks in winter only to 40°. Winds from the lake, therefore, partaking largely of the temperature of the water, must exert a material influence in equalizing the land temperatures of summer and winter. Still more, in cases of extreme weather, when the land temperature rises to 95° or sinks to 30° below zero, must the ameliorating influence of such a vast body of water, holding itself steadily at a somewhat uniform temperature, be most conspicuously and most beneficently experienced.

Observations have shown that even the annual means of the regions contiguous to the lakes are somewhat raised by the lake influence. The cooling effect in winter is not equal to the warming effect in summer. In other words, the mean temperature of the lake is a few degrees higher than that of the land. As this fact cannot be attributed to an influx of river water from more southern latitudes, and would seem to be only partially explained by the probably higher temperature of river waters in the same latitudes, it remains to seek an explanation of the higher mean temperature of the lake. Now, let it be remembered that the waters of the lake penetrate 900 feet toward the heated interior of the earth; and that it has been ascertained that on the land every fifty-five feet of descent beneath the plane of constant temperature brings us one additional degree of heat. It will thus appear that if the depth of constant temperature in the mean latitude of Lake Michigan is 60 feet, the water of the lake reaches a depth where the terrestrial temperature should be 15° higher than the constant temperature beneath the land, which would probably be about the mean annual temperature of the locality. The writer has ventured heretofore to suggest that, though the cooling influence of the local annual mean must have been felt by the earth in the bottom of the lake, it must be still true that the bottom of the lake has felt somewhat the warming influence of the normal terrestrial temperature at that depth. It seems, therefore, entirely reasonable to maintain that the heat of the earth's internal fires contributes something to the excess of the lake's mean warmth over the mean warmth of the land. The great lake may, therefore, be conceived as held in a vast natural dish, which is warmed over the imperishable fire which we know to be imprisoned within the earth. When the temperature of the land sinks to 20° or 30° below zero, that of Lake Michigan is 60° or 70° higher; and the vapor which ascends from its surface is the literal similitude of the steam rising from a kettle heated over a domestic fire.

Two local factors enter into the rational explanation of the peculiarities of the climate of the lake region. One of these is the equable temperature of great bodies of water, the other is the prevailing direction of the wind. To illustrate the latter more precisely than has been done, let us consider the peninsula of Michigan. Were the atmosphere perpetually calm, the contiguous land and superincumbent atmosphere would only be very feebly warmed during winter by direct radiation from the lake; and this effect would be more than counterbalanced by a perpetual land breeze as long as the lake should remain warmer than the land. But the general atmosphere is always in motion. Warmed in winter, while passing over the surface of the lake, it conveys some part of the lake-warmth to the land, and the rigor of the cold becomes ameliorated, on the principle of a hot-air furnace. As the wind by turns moves from all directions, the lake exerts some warming influence on all the surrounding land. This is illustrated by the isothermal lines for the cold months, which are bent northward on approaching the lake from either side. Evidently that side of the lake which receives most wind from the lake-surface will be most impressed by the lake-influence. Now it happens that the Michigan side of Lake Michigan receives most lake winds during the cold season, because, as is well known, the cold winds of the region approach from a westerly direction. Thus in January, at Chicago, according to eleven years' observations, the winds from the west of the meridian are to the winds from the east of the meridian as 72 to 5; at Milwaukee, for thirteen years, as 60 to 18; at Manitowoc, for eleven years, as 67 to 11; at Grand Haven, for one and a half years, as 34 to 16. A similar excess of westerly winds is shown for all the months of the year except April and May, and especially the month of May.

In consequence of this prevalence of westerly winds the east side of Lake Michigan is warmed in winter and cooled in summer. While, therefore, the winter mean at Chicago is 24½°, that of New Buffalo, in the same latitude, is 28°. While that of Milwaukee is 22°, that of Grand Haven is 26°. While the winter mean of Fort Howard is 20°, and that of Appleton 19°, the winter mean of Traverse City, farther north than either, is 23½°. In autumn, also, the preponderance of westerly winds raises the mean temperature one or two degrees along the south half of the lake shore, and three to four degrees along the northern half of the shore. This is strikingly shown on an isothermal chart where continuous lines are drawn from east to west through places having the same autumnal means. To the west of the lake region the lines conform approximately to the parallels of latitude, but over and east of Lake Michigan they bend abruptly northward. The autumnal isotherm of 46°, which passes through Fort Winnebago, bends northward nearly to the extreme point of Lake Michigan, a difference of latitude of about 185 miles. The isotherm of 47°, which passes through Fort Atkinson, bends northward to the Beaver islands 192 miles. The isotherm of 48° is deflected northward an equal distance. The isotherm of 49° sweeps from Evanston, near Chicago, to the mouth of the Manistee river, a difference of latitude of 152 miles. The isotherm of 50° bends from Kensington, south of Chicago, to Grand Rapids, a difference of latitude of 97 miles. The favorable contrast diminishes in the southern portion of the eastern shore, since in November the cold southwesterly winds either miss the lake entirely or are held at a lower temperature by mingling with wind which has not traversed the lake. These statements relate to the mean autumn temperature of the two sides of Lake Michigan. They show that the autumn temperatures along the west side are found on the east side from *one to two hundred miles farther north.* To put the subject in another light, an investigation of the monthly means on the opposite sides of the lake during autumn shows that the temperature attained at Milwaukee October 15 is not reached at Grand Haven until October 20. The Milwaukee temperature of November 15 is only reached at Grand Haven November 23. The Chicago temperature of September 15 is the same as the New Buffalo temperature of September 21. These comparisons show that the warm season is lengthened on the east side about six to eight days in the autumn. In 1865 the first killing frost in the Grand Traverse region was December 2; in 1866, November 15; in 1867, November 18. These particular facts are cited because they fell under the writer's observation.

By a singular and happy exception in the prevailing direction of the wind, we find that during the month of May winds from the east of the meridian preponderate. This is shown again from an extensive series of meteorological tables, since at Manitowoc the easterly winds in May are to the westerly as 37 to 26; at Milwaukee as 62 to 24, and in April as 52 to 33; at Chicago, including north winds, which are here lake winds, the ratio of lake and land winds is in May as 44 to 40. Now, in May, a lake wind is a chilling influence, except when the thermometer is sinking below the growing temperature for vegetation. It is then an influence which prevents frost. It follows, therefore, that during the mild days of May the eastern shore of the lake is exempt from the chilling and retarding influence of westerly winds; while, during a cold period, when, as a rule, the wind is westerly, the eastern shore receives the benefit of protection from frost. Thus, on the 16th of May, 1868, a destructive frost occurred throughout Illinois, Indiana and Ohio, but did no damage in the Grand Traverse region. It is a frequent occurrence to read of killing autumnal or vernal frosts in any of the states south or west of Michigan, while the Michigan peninsula remains completely exempt. This unique arrangement of the prevailing winds seems prompted by a beneficent regard for the interests of early vegetation on the eastern side of Lake Michigan. Westerly winds cease to predominate only in that month when they cease to be beneficial to Michigan. And yet even in that month they exist whenever the interests of vegetation demand. Not only do westerly winds cease to predominate at the juncture when they cease to be beneficial, but at the same juncture, the warmer land winds from the east of the meridian become predominant. Both causes accelerate vegetation on the east side of the lake. A study of the means for a series of years, at places on opposite sides of the lake, shows that the temperature of

Grand Haven March 15 is equal to that of Milwaukee March 21; that of Grand Haven April 15 is equal to that of Milwaukee April 24; that of Grand Haven May 15 is equal to that of Milwaukee May 28. These are not single instances, but comparisons of results of many years of accurate instrumental observation. They show that in May Grand Haven is thirteen days in advance of Milwaukee. Add the thirteen days of growing weather gained in spring to the five days gained in October, and we perceive that the growing season is eighteen days longer at Grand Haven than at Milwaukee. Every practical cultivator knows that eighteen days often make all the difference between a crop well ripened and perfect and a crop immature and savorless, if not ruined by an untimely freeze.

This contrast is the same in kind as exists along the whole length of the two shores; but we find it qualified by two influences. First, the northern portion of the western shore receives a warming influence from northerly winds approaching over Green Bay; but, at the same time, the greater expanse of water passed over by westerly and southwesterly winds approaching the Grand Traverse region imparts to that region a greater relative influence than is felt by the Grand Haven region. Secondly, the southern portion of the Michigan shore of the lake is exposed to the unmitigated sweep of southwest winds, which, in the northwestern states, are often the coldest of all; but, on the contrary, this region receives northwesterly, and even north, winds which have swept over a vast expanse of lake surface.

I have thus far referred only to annual and seasonal means. The longer the period embraced in the computation of a mean, the more the salient features of the climate are disguised. The annual mean in the Lake Region approximates that of other districts in the same latitude, since the cooling effect of the lakes in summer is neutralized in the annual mean by the warming effect in winter. We approach nearer an expression of the local peculiarities of the climate by comparing, as we have done, the seasonal means. But we approximate still nearer an exhibit of the special climatic conditions by making comparisons of monthly means — especially for those months whose temperatures depart most from the annual mean, and from the mean temperature of the lake water. These months are July and January.

If we inspect the isothermal chart for July we shall observe a series of lines drawn through localities of equal mean temperatures, within the limits of the region affected by lake influence, and extending far enough westward to reach the general continental conditions. The first thing which impresses one is the extreme *southward* deflection of all the lines in the vicinity of Lake Michigan, and a similar, though less abrupt, deflection in the vicinity of Lake Huron. Tracing, for instance, the line of 70°, we find it entering from the west on the parallel of 48°. Its course is southeast, under the influence of continental conditions, as far as Fort Ripley, in Minnesota, whence it passes nearly eastward to the valley of the Menominee River. Here it comes under the decided influence of Lake Michigan, and rapidly bends southward, passing through Green Bay and Milwaukee, in Wisconsin. Reappearing at Grand Haven, in the peninsula of Michigan, it trends almost directly northward to Traverse City, whence it arches across the peninsula till, coming within the influence of Lake Huron, it bends southward again and passes into Canada, near the southern extremity of that lake. It passes thence in a northeasterly direction to Penetanguishene, on Georgian Bay. This isothermal is deflected, through the influence of the lakes, to the extent of 5° of latitude, or 350 miles in a straight line. The general course of all the isothermals from 67° to 75° is extremely similar to that just traced.

It follows, from these indications, that an almost identical July temperature stretches along the two shores of Lake Michigan from Chicago to Mackinac. It appears, however, that the immediate western shore is somewhat more cooled than the immediate eastern. This results, as a careful investigation has shown, from a slight preponderance of winds in July from points east of the meridian. At Chicago this preponderance, including north winds, is as 60 to 33; at Milwaukee, as 48 to 37. But at Milwaukee and northward, northerly and even northwesterly winds feel the influence of Green Bay.

Further inspection of these isothermals discloses the fact that the July temperature of the peninsula of Michigan is about the same as that of the interior of Wisconsin in the same latitudes; but the heat of the Mackinac region is considerably less than that of Wisconsin and Minnesota on the same parallels. This accounts for the popularity of Mackinac as a place of healthful summer resort. On the contrary, the heat of the central and southern portions of the peninsula is equal to that experienced through the northern half of the states of Indiana and Ohio two or three degrees farther south. The July temperature of Marietta, Ohio, is 73½°, which is the same as that of Flint, and less than that of Grand Rapids, Michigan.

Another effect of the perturbating influence of the lakes, reacting upon topographical and continental relations, is to cause certain isothermals to divide and, by reuniting, to inclose detached areas, which stand like islands of cold or heat. An example of the former exists in the peninsula of Michigan, and one of the latter in Iowa. The greater part of Ohio, however, seems to constitute an island of uniform temperature in July, since from Cleveland to Marietta and Portsmouth, the mean is not far from 73½°.

The distribution of the January isothermals possesses still greater interest. It is the severity of our winter climate rather than the character of summer which, in our northern states, conditions the growth and health of most of our perennial exotics, as peaches, apples and improved varieties of grapes. With a glance at the chart of January isothermals, the eye is first arrested by the general *northward* deflection of the lines in the vicinity of Lakes Michigan and Huron. This direction is the reverse of the July inflection. The isothermal of 23°, for instance, which passes through Peoria, Illinois, enters the southern extremity of Lake Michigan, and proceeds directly to Northport, at the mouth of Grand Traverse Bay. It thence sweeps southward to Lansing, when it returns northward, under the influence of Lake Huron, to Thunder Bay Island and finally bends eastward, passing forty miles south of Penetanguishene in Canada.

Similarly, the isotherm of 27° sweeps from southwestern Michigan through Springfield, Illinois, and thence to Fort Riley, in Kansas, near the latitude of 39°. Eastward, the same isotherm strikes through Central Indiana and Ohio. The January climate of New Buffalo is as mild as that of Cincinnati. Traverse City corresponds, in this respect, with Omaha, Muscatine, Ottawa and Aurora. Mackinac and Marquette compare with Green Bay, Fort Winnebago and Prairie du Chien. The isotherm of 22° is deflected by the influence of Lake Michigan over a belt of four and a half degrees. This is more than 300 miles in a straight line, and is equal to the distance from Mackinac to Fort Wayne.

Another fact strikingly exhibited is the difference between the January temperatures along the opposite sides of Lake Michigan. The mean at Chicago is 22¼°, while that of New Buffalo, directly opposite, is 30°. The mean of Milwaukee is 20½°, while that of its *vis-à-vis*, Grand Haven, is 25°. The mean of Green Bay is 19°, and that of Appleton 15½°, while that of Traverse City is 22°. Greatly as the January climate along the western shore is ameliorated by the influence of the lake, that along the eastern shore is still further ameliorated to the extent of four to seven degrees. This contrast results from the prevailing direction of the cold winds, which, in the Northwestern States, is from the west and southwest. The results of observations made in January have already been given. These results embody all January winds except those directly from the north or south.

At the same time the January climate along the eastern border of the peninsula of Michigan is not much more severe than that along the western, though the prevailing winds along the eastern shore, as in Wisconsin and Illinois, are from the west of the meridian, and carry the influence of Lake Huron away from the land. This state of things is accounted for by three considerations. First, the influence of Lake Michigan is distinctly felt across the entire peninsula. The mean of Flint, for instance, is four degrees above that of Prairie du Chien, on the same parallel. The narrowing of the peninsula northward emphasizes this consideration. Secondly, Lake Huron exerts its proper influence upon the western shore, which reinforces that brought from Lake Michigan. Thirdly, the intrusion of Saginaw Bay into the interior throws a large area to the east and southeast of this body of water. It may also be mentioned that the position of this bay, and the peculiar bend of Lake Huron toward the west, are such that even north winds must come somewhat tempered by these great natural stoves. It is certainly a singular circumstance that, while Manitowoc, Milwaukee and Chicago, on the west shore of Lake Michigan, have lake-winds during January, represented by the numbers 11, 18 and 7 respectively, Thunder Bay Island, Ottawa Point and Fort Gratiot, on the west shore of Lake Huron, have winds from that lake during January, represented by the numbers 51, 86 and 35. These numbers embrace north winds at Chicago and the points on Lake Huron, and southwest winds at Ottawa Point, as these sweep along the axis of Saginaw Bay.

The isothermal chart of the lake region for January exhibits in the country south and southwest of Lake Superior a series of remarkable loops. The great isotherm of 14°, for instance, coming down past the head-waters of the Minnesota river, passing near Saint Paul, and continuing southeastward to the 44th parallel, begins to feel the influence of Lake Michigan, and bends northeast through the region west of Green Bay to the narrow peninsula north of Lake Michigan, where, under the influence of Lake Superior, it loops west again, passing south of Marquette and Ontonagon to Bayfield and Duluth, whence, bending east a second time, it passes near Beaver Bay in Minnesota, and crossing Keweenaw Point emerges upon Canadian soil some forty miles to the north of Sault Ste. Marie. The loop which opens westward denotes the position of a zone of cold located along the elevated district which forms the water-shed between Lake Superior and the Mississippi. The axis of this zone, instead of lying along the head-waters of the streams flowing north and south, is crowded southward, apparently, by the influence of Lake Superior. The other loop, which opens eastward, is a zone of warmth stretching along the south shore of Lake Superior from Ontonagon to the Sault Ste. Marie. An island of cold seems to be located in the southern portion of the lower peninsula of Michigan, and another in northern Iowa. An area of uniform temperature stretches across middle Ohio, as we have already seen to be the case also in July.

There is a method of obtaining a still more precise, and therefore more correct, expression of the distinctive characteristics of the climate of the lake region. Averages of months and seasons suffice, indeed, to indicate the length of the growing period and the average severity of the winter. But there is another aspect of climate which possesses at least equal importance; though in climatic discussions it has been largely overlooked. Published tables give us means of the year and of the several seasons, and their authors seem to think that in this they have brought to view all the important elements of climate which bear on health and production of crops. A little reflection, however, shows that the *extremes* of climate are of equal importance with the means. It signifies little that the growing season begins in March, if liability to killing frosts continues to the middle of May, as in Tennessee. A mean October temperature of 60° is comparatively valueless after a September freeze. The mean temperature of a season may be mild, or even delightful, at the same time that one or two days have brought destructive cold. One killing frost is as bad as a dozen, for vegetation has but one life to destroy. It is the liability to these exceptional temperatures which we must know before forming final judgment on the adaptability of a district for a particular crop. A winter which averages mild may be marked, like the climate of Saint Louis, by one, two or three mornings destructive to everything which would triumphantly survive all the rest of the season. Every fruit-raiser knows that it is not the average weather of winter or spring which endangers his buds or his trees. It is the one or two nights of the whole season which brings him apprehension,— especially if accompanied by high wind. It is of no consequence that the winter mean of Saint Louis is 33° and that of Grand Haven 21°, or of Traverse City 24°, if the thermometer falls sometimes 22° below zero at Saint Louis and never sinks more than 16° below zero at Grand Haven or Traverse City. It is precisely against these exceptional extremes that the great lakes exert their most striking influence.

There are two ways to consider extremes of climate. We may consider the *mean* minimum of a locality, or its *extreme* minimum, for a series of years. There is a lowest point reached by the thermometer at each locality every winter. Different winters may vary greatly in the severity of the coldest day, but we may take the average of a series of winters. This is the *mean minimum.* It indicates the lowest temperature which the locality is as likely to experience as to escape. Now, from this point of view, the climate of the lake region stands forth singularly favored. If on a map of the Northwest we draw lines through all the places having the same mean minimum, we shall be surprised to notice to what an extent all the lines are bent northward along the immediate vicinity of the lake. They do not trend east and west, as they must under the normal influence of latitude, but they run literally north and south in the vicinity of Lakes Michigan and Huron. The isotherm of the mean minimum of fifteen degrees below zero strikes from Mackinac through Manitowoc, Milwaukee and New Buffalo, to Fort Riley in Kansas, near the parallel of 39°. Here is a deflection of nearly seven degrees of latitude, or about 480 miles in a straight line. The meaning of this is that the most excessive cold at Mackinac, for a period of twenty-eight years, is not, on the average, greater than at Fort Riley, 480 miles farther south. It is one degree less than at Chicago for a term of eleven years. The coldest days of winter are, on an average, no more rigorous at Mackinac than those of Peoria, Illinois, or of northern Missouri. If we add to these equal quantities of cold the amount of *wind* characteristic of each region, it is at once apparent that the balance of sensible and damaging cold turns promptly against the more southern localities. There is no point along the eastern shore of Lake Michigan where the mean minimum is lower than minus 6°.

One is led to remark, in this connection, the important bearing of the facts disclosed upon a great enterprise so vigorously advocated a few years since by Hon. Edgar Conkling, in reference to the founding and endowment of a national university at Mackinac. They furnish the exact and inductive basis of the reputation for salubrity which has long been enjoyed, to some extent, by the region of the northern lakes. They demonstrate that Mackinac possesses, both in its summer and its winter climate, those conditions of comfortable equability of temperature, freedom from violent winds, and entire exemption from malarial influences, which constitute the medical man's ideal of a resort for invalids, and a region suited to the rearing of vigorous, strong-bodied and strong-minded men and women. Though the university project never advanced beyond the stage of energetic advocacy, one can clearly perceive that with the opening of railroad communication and the dissemination of a knowledge of the facts, Mackinac is destined speedily to assume the character of a summer resort more delightful than Long Branch, and only less frequented in consequence of the latter's proximity to New York. But no one can anticipate at Mackinac, that unpleasant and expensive herding of so many thousands within limited quarters, which characterizes some seaside resorts, since the region of Mackinac extends on the east to Cheboygan, and on the west to Grand Traverse Bay. Already, at the head of Little Traverse Bay, Petoskey has become the summer Mecca of thousands fleeing from tropic heats, and exhausting business, and annoying hay-fevers, and pernicious malaria.

Suppose we note the lowest point reached by the thermometer in a series of years at each of fifty localities.

These points are the *extreme minima* of the several localities. Now, drawing a line on a map through all the localities which have the same extreme minimum, we have an isothermal chart for extreme minima. Its features are similar to those of a chart of mean minima, but still more pronounced. Here we see the lake influence exerted under its most exaggerated and astonishing aspects. The line of extreme minimum of minus 25°, for instance, strikes from Leavenworth, in Kansas, to Ottawa and the vicinity of Chicago; thence along Lake Michigan, a few miles east of Milwaukee, to the immediate vicinity of Mackinac. The isotherm of minus 24° strikes Saint Louis, and passes thence through Central Illinois and Indiana, and thence northward through Michigan at the distance of thirty-five or forty miles from the lake shore to the latitude of Thunder Bay, whence it descends along the eastern slope of the peninsula, and continues south even to the Ohio river.

To put the facts in a different light, it appears that the lowest point reached at Mackinac in twenty-eight years is but two degrees lower than the extreme minimum of Saint Louis. Extreme weather at Chicago is twelve degrees colder than at New Buffalo. The lowest extreme of Milwaukee is fourteen degrees below the extreme minimum of Grand Haven, while the extreme of Fort Howard is twenty degrees below that of Northport. In general, while the mean minimum along the west side of Lake Michigan is minus 16°, that along the east side is minus 6°; while the extreme minimum on the west side is minus 22° to minus 30°, that of the east side is minus 10° to minus 16° as far north as Little Traverse Bay. On that day of memorable cold, January 1, 1864, the thermometer sank to minus 30° at Milwaukee, but only reached minus 14° at Northport and Traverse City. At the same time it was minus 29° at Chicago and minus 20° at Kalamazoo. It sank to minus 24° at Saint Louis and minus 16° at Memphis, Tennessee. This point was two degrees colder than Northport, 640 miles farther north in a direct line. The isotherm of minus 24° bends from the latitude of Alpena, through Grand Rapids, Battle Creek and Coldwater, and thence to Saint Louis, 452 miles farther south. Cincinnati is reported to have an extreme minimum of minus 29°, a degree of cold not known in the peninsula of Michigan, and but little exceeded along the south shore of Lake Superior. At Ann Arbor the lowest point reached in twenty-eight years is minus 24°. On January 1, 1864, it was minus 18° at Ann Arbor. The area of the extreme minimum of minus 24° seems to cover all the central portion of the peninsula east of Grand Rapids, west of Bay City, and south of Otsego Lake, and stretches southward into central Kentucky. Compared with Traverse City, the extreme minimum of Hazelwood, Minnesota, is 22° lower; that of St. Johnsbury, Vermont, 28° lower; that of Gardiner, Maine, within thirty miles of the ocean, 19° lower, and of Montreal 26° lower.

A few more specific illustrations may be added. On the 18th of November, 1880, while the thermometer was 5° at Milwaukee, it stood at 18° at Grand Haven and at 10° at Port Huron. At the same time it was 8° at Saint Louis, 2° at Denver, 4° at Dodge City, Kansas, and 6° as far south as Fort Gibson, Indian Territory. On the 19th of November, while the thermometer marked 29° at Grand Haven, it was 13° at Port Huron; and farther south it marked 14° at Chicago, 2° at Indianapolis, 11° at Louisville, and 8° at Saint Louis. But lest it be thought such contrasts between the extreme cold of the lake region and that of other points, taken simultaneously, may arise from the progressive character of cold centers, let us take the cycle of December 28–29, 1880, and compare, without regard to simultaneousness, the lowest points reached at different places. The thermometer during this cycle reached minus 30° at Duluth and minus 16° at Marquette, in nearly the same latitude, but protected by Lake Superior. It was minus 37° at Saint Vincent and minus 41° at Fort Garry. In a lower latitude the mercury sank to minus 25° at Saint Paul and minus 20° at Escanaba, while at Alpena, in the shelter of the lakes, it only attained minus 10°. Still farther south we found it minus 20° at Lacrosse and minus 19° at Milwaukee, while only minus 8° at East Saginaw. Finally, on the parallel of Ann Arbor the thermometer stood at minus 16° in the peninsula of Michigan, while west of the lakes it stood minus 23° at North Platte, minus 12° at Indianapolis, and minus 13° at Saint Louis.

The peninsular situation of Michigan between the lakes is something which arrests the attention of the most casual observer of the map of the Northwest. It is not apparent to observation, however, that Michigan is also a climatic peninsula; and yet the facts which have been cited in this paper show that its climate, in its seasonal means, is a patch taken from the latitude of Ohio; while in the moderation of its extremes it bears an analogy to the Floridian peninsula. Its climate is cut off from that of Wisconsin and Iowa by a barrier as abrupt and as real as that which limits its territory. That which constitutes the barrier in the one case creates it in the other.

While the whole eastern shore of Lake Michigan enjoys the combined advantages of lake influence, and peculiar arrangement in the prevailing direction of the wind, there seemed to be still another expedient by which these advantages could be enhanced and distributed over a wider belt. There is a singular, and, one could almost believe, providential, conformation of this shore of the lake which greatly augments its ameliorating influence on climate, and, at the same time, creates important facilities for shipment and transportation of the products of the soil. Anyone looking at an *ordinary* map of Lake Michigan would at once conclude that the rigid continuity of the coast-line excluded the possibility of all harbor accommodations from Chicago to Grand Traverse Bay. It is true that we find few harbors in a state of preparation for occupancy; but it is a singular and interesting and most important fact that there is not a stream, however small, emptying into Lake Michigan from the east which does not first discharge its waters into a small lake which communicates almost immediately with Lake Michigan. Looking at a representation of this hydrographic singularity, one can hardly resist the fancy that we have here a real litter of lakelets nestling alongside of the great maternal lake. These baby lakes are bodies of clear water, with clean, sandy shores, and abound in delicate fish. Toward the north they contain the speckled trout in abundance, while many of the streams which debouch through them are stocked with that game-fish whose pursuit is so exhilarating to anglers, the "grayling," first described from the waters Michigan. We find over thirty of these lakelets between St. Joseph and Little Traverse

Bay, while at least a dozen of them furnish depth of water sufficient to float the largest lake steamers.

The geological explanation of this phenomenon is not difficult. The surface sands of the peninsula have for ages been in process of transportation by the moving waters from the interior to the great lake. The stream of sand is met by the waves, and a bar is formed which, in time, obstructs the outlet. In some cases the water is dammed, and the lakelet is formed directly; in others the stream passes off laterally between the bar and the mainland, the current gradually wearing away the bar and widening the water-way on the eastern side, while the action of the waves in throwing up the sands widens and develops it into a high barrier on the lakeward side.

The climatic effect of these numerous smaller bodies of fresh water — stretched like a string of pearls along the skirt of the peninsula — is to widen the belt of lake influence, and to temper the cold approaching from almost every direction. They also multiply many fold the length of coast-line, and furnish innumerable sites enjoying a water aspect. As the banks of all these lakelets are elevated and dry, the lengthening of the line of lakeside situations is a circumstance of very great moment.

It is worthy of remark that when we look along the *western* shore of Lake Michigan for the counterpart of this string of lakelets it is not there. The eastern shore monopolizes again all the advantages. Blessed be the west wind, which, though it pinches the squatter on the prairie, and by the hands of its servants, the waves, digs down the eastern borders of Wisconsin, heaves up piles of sand upon the shore of Michigan, making unwearied additions to the land, and building up the terraces of our crystal lakelets to furnish a "lake view" for every homestead along the border of the "beautiful peninsula."

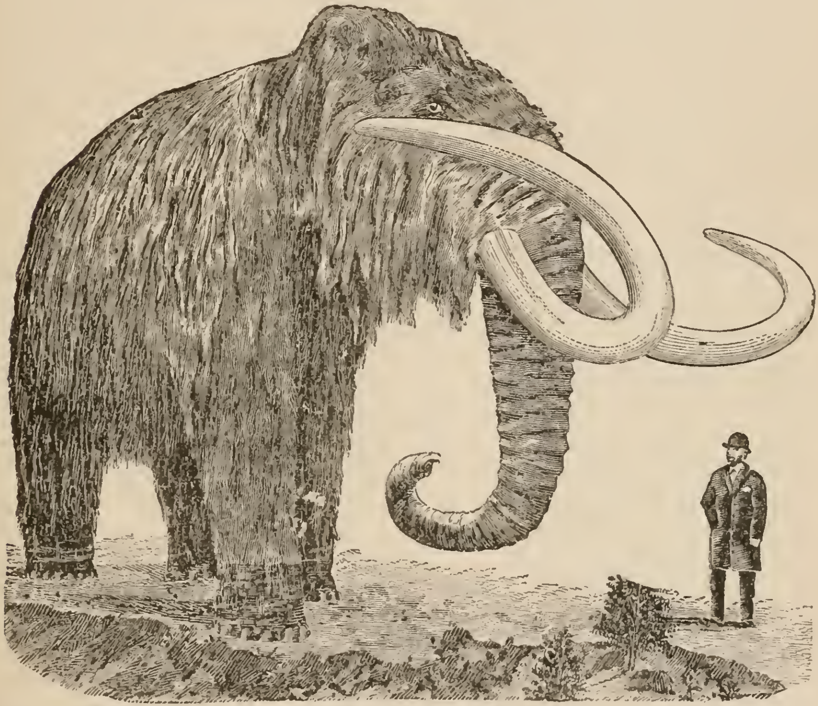
The climatic peculiarities of the eastern shore of Lake Michigan, in the neighborhood of Saint Joseph, began to be understood many years ago. At least, it had been empirically discovered that the region is favorable for the growth of the peach. But it is certain that no one would have believed, before 1866, that an almost identical winter climate stretches as far north as Grand Traverse. In 1866 the present writer set forth the statistical evidence of the fruit-producing capacity of the whole lake shore; and in 1867 the incredulity of the Secretary of the State Board of Agriculture for Michigan prompted him to an official investigation, which ended in a complete vindication of all the claims set up for "The Fruit Belt of Michigan." At the present time it is demonstrated from experience that all the way from New Buffalo to Northport, a distance of 225 miles in a right line, fruit-trees and shrubs which escape destruction through the winters of central Illinois and Missouri enjoy complete immunity. During the period of verdure, the genial influence of the lake secures them from the early and late frosts, which are not unfrequently felt as far south as Missouri, Kentucky and Tennessee. The growing season is consequently as long, and very nearly as warm, as that of central Illinois. The equability of the climate is considerably greater; while the persistent and chilling and destructive winds which frequently visit the southwest are comparatively unknown. At the same time, the soil of the entire belt, from Indiana to Grand Traverse Bay, is worthy of the climate. Though decidedly sandy, and at first view uninviting, it is proved, both by investigation and experience, to abound in those alkaline substances requisite for the highest luxuriance of ordinary vegetation.

In accordance with these conditions, the entire lake shore, for a breadth of twenty to forty miles, is becoming rapidly converted into orchards and plantations for the rearing of all the different fruits known in the temperate zone.

MAMMOTHS AND MASTODONS.

ALMOST every one is aware that the mammoth was a quadruped of huge dimensions. The name has been transferred to other objects of extraordinary magnitude. The mammoth is generally understood to have been an elephant-like creature, possessing the majestic mien and ponderous tread of the living proboscidians of Africa and India. But no one could fail to stand aghast with amazement at the magnitude of the truthful restoration of the creature, as first exhibited in this country, three years ago, in the Natural Science establishment of Professor Henry A. Ward, of Rochester. Menageries have made us all familiar with the bulky and graceless grandeur of the modern elephants. We have seen in America a number of mounted skeletons of the extinct mastodon; while the bones and teeth of this elephantine predecessor of man have fallen under the observation of almost every child. But nobody had adequately conceived the astonishing magnitude to which the old mammoth of Europe, Asia and America sometimes attained. Within a few years the monster has been carefully reconstructed, and Professor Ward's enterprise has introduced him to the notice of American geologists and the American public. Permit me to recall the impressions made by a visit to the Rochester establishment.

As the visitor enters the door of the building, which has been erected for the accommodation of this antediluvian, a dark mountain of flesh rises before him. He had gauged his apprehension to the familiar bulk of the elephant, but here his eye must be lifted to a higher altitude; his whole thought must swell to take in the idea of the towering form which looms above him and frowns darkly and severely down upon him. The monster's brow rises like some old granite dome, weather-beaten and darkened by the lapse of geologic ages. Two winding streams of ivory descend like glaciers from the base of the dome, while the corrugated and beetling proboscis swells between them like the embattled crest which di-



THE HAIRY MAMMOTH RESTORED. FROM A RESTORATION IN THE ESTABLISHMENT OF PROFESSOR H. A. WARD, ROCHESTER, N. Y.

vides two Alpine glacier-torrents. Behind expands and uprises the mountain mass of which these are the accessories. Serene and motionless as Mont Blanc this majestic form stands awaiting our wonder and adoration. No astonishment disconcerts it; no exclamations stir a feature. Unlike the dumb mountain, however, this form seems in a mood of contemplation. All this dark and towering mass is conscious. There are eyes which open on us and take cognizance of our movements; there are ears which take in the sounds of our voice. This creature contemplates us; he throws a spell over us; he has us in his power.

The mammoth! aye, the mammoth of mammoths! With a long breath, after this suspense of amazement, we extricate ourselves from his spell, and meet his overpowering stare with the force of intelligent will. He is but a beast,—let us analyze the sources of his power over us. He stands sixteen feet in height. His extreme length is twenty-six feet, and the distance between the tips of his tusks is fourteen feet. His body is thirty feet in circumference close to the skin. The sole of his foot is three feet in diameter. His tusks are fourteen feet long and one foot in diameter at the base. Between his short, post-like fore-legs a man can stand upright with his hat on without touching the animal's body. The whole exterior is clothed with dark, shaggy hair, quite unlike the modern elephants, and under the throat it attains a length of twelve to fifteen inches. There is a gallery in this building, and the monster's eye is nearly on a level with it. We ascend to the gallery to obtain a more commanding position, and there experience a sensible relief in finding this formidable creature partially beneath us.

But this may be all a pure fabrication,—in conception as well as in construction,—like the "Trojan Horse," or the bronze statue of Bavaria at Munich, whose hollow head will receive six men and women at once. What evidence have we that such a beast ever lived? Aye, there's the important point. Now, I have examined this question. I have some personal knowledge, and I have received some reliable testimony. First let me give a little history of this Wardian mammoth.

This specimen was manufactured in Professor Ward's establishment,—itself a worthy object of national pride, since no equal establishment of the kind exists in the world. But it was modeled after an original restoration purchased at Stuttgart. The original was made by the distinguished preparator L. Martin, who worked under the direction and advice of Dr. Oscar Fraas, the celebrated geologist and comparative anatomist of Stuttgart. The Royal Museum at Stuttgart is one of the richest in the world, and in certain departments it surpasses all. Here had been preserved for some years various bones of the extinct elephant which once roamed over Europe. Here was a thigh-bone and there a vertebra; here a tooth and there a portion of a skull; here a tusk and there an ulna or a metacarpal. I well remember how these numerous huge brown relics of an extinct world commanded my attention when formerly making a study of this museum. Now, every bone sustains a certain relation to the entire bulk of the animal to which it belonged. Indeed, so great is the uniformity of correlations of parts that we safely affirm that if one elephantine bone was twice the bulk of another of the same name, the animal which used it was twice the bulk of the other,—exactly as the Greek sculptor proceeded to model a colossal figure from the known proportions of the normal one. The living elephants from different regions, and of different varieties, ages and sexes, have long been known to comparative anatomists. There is little variation among them in the ratio of a given bone to the whole length or height of the animal. Now, as the mammoth was an elephant, the known ratio of thigh-bone to the animal would enable the anatomist to construct the animal from the bone,—from a single bone. But in the case of the mammoth, every bone of the skeleton had somewhere been discovered. With such knowledge the Stuttgart specimen was reconstructed. The left tusk, with all its enormous magnitude, was literally moulded over a real tusk, and the right is simply made to correspond. Dr. Fraas, in writing on this subject, after saying he felt "homesick" for another sight of the old Colossus, the erection of which he had superintended, personally guarantees the accuracy of the reproduction as to size and proportions, and states that Herr Martin took accurate measures for every part from original bones. He admits, however, that some doubt may exist as to the color of the hair, and its length upon the tail and the throat of the animal. The very conditions of the case preclude absolute certainty here. But in respect to these points, as in the form and pose of the creature, the reconstructor has been guided by actual specimens, including a nearly complete skeleton preserved in the Imperial Museum at St. Petersburg, to which I shall presently refer.

The framework of the restoration was of timber. Over this the contour of the body was skillfully shaped, and the whole was covered by a skin. To this was applied an artificial covering of hair of proper length, and dyed the appropriate color. And thus was reproduced, as nearly as science and art could accomplish it, the verisimilitude of the living mammoth which once thundered through the forests and jungles of the Old World and the New.

This extraordinary product of human skill arrested the attention of Professor Ward. He was on his way to Egypt, Abyssinia, and the Red Sea, in search of the treasures of the animal and mineral kingdoms to stock his collection and supply the demands of American colleges and universities. He endeavored to purchase the specimen, and the reader may like to know that it was held at the exorbitant price of 60,000 marks, or $15,000. On his return, however, he telegraphed from Paris the offer of a sum which was accepted. Repairing to Stuttgart, he subjected the beast to a process of dissection, and after much labor reduced it to a condition suited for transportation to America.*

The present specimen was built by Professor Ward and his imported preparators after the model of the original, but with several minor improvements. It consists of thirty-two separate pieces, and is specially adapted to dismounting for transportation. The hair is rendered incombustible by steeping in a solution of tungstate of soda.

A reproduction so unique of a prehistoric monster whose relics, scattered over the breadth of our continent, have excited the wonder and inquiry of every American citizen, possesses much more than a commercial importance. Here, at length, is the full embodiment of the creature whose teeth and bones our bogs have been yielding up for a couple of centuries past. Some of us have seen the ponderous bones of his near relative, the mastodon, bolted together in due order, in the museums at Boston, Albany, Chicago and elsewhere, but this mightier proboscidian has never furnished us a complete skeleton. Still stranger to American eyes is the towering shaggy form of the mammoth as clothed in flesh and elephantine fur. This and the mastodon are the beasts of which our Indians preserve some distinct traditions. This is the beast once hunted by the prehistoric inhabitant of Europe. It was the figure of such game that European man in the Stone Age sometimes etched on plates of ivory. It is a coincidence of great interest that palæolithic man in America was a co-tenant with the same quadruped, and executed similar sketches upon the animal's own ivory; for in at least two instances such outlines, traced on ivory, have been taken from "mounds" in the Mississippi valley. By our relationship to the primitive populations of two continents, therefore, our interest impels us to learn more of the life and times of the colossal game which was once pursued with rude implements of flint and bone.

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* It will contribute some numerical values to our apprehension of the bulk of this monster to read the following statements: Ten workmen were occupied six days in taking the creature to pieces and packing it in fourteen enormous boxes for shipment. The total weight was 14,694 pounds, and so bulky was it that it loaded four German freight cars. The freight charges from Stuttgart to New York were $682, and from New York to Rochester by canal $86.

History has preserved no mention of the existence of the mammoth in the living state; but its bones are scattered over the whole of Europe and northern Asia as far as Behring's Straits; even on the American side of the straits they occur in similar abundance. But it was, according to prevailing scientific opinion, a somewhat different species of mammoth which left its remains throughout the United States, and even as far as Mexico and Central America. Still another species ranged from Honduras to Peru. Scientists have designated the first mentioned the "primeval mammoth" (*Elephas primigenus*), and our own species the "American mammoth" (*Elephas Americanus*). The other species is the "Andean mammoth" (*Elephas Andium*). Like modern elephants, the mammoths probably delighted in water and mire, and sometimes indulged, like the rhinoceros and the well-known pig, in the dirty habit of "wallowing" in the mud. This instinct tempted the huge creatures into treacherous bogs, in which they seem sometimes to have sunk beyond recovery; for their bones are frequently preserved in beds of peat, and the skeleton is occasionally found in an erect position. Their tusks occur in northern Russia in such abundance as to supply an important part of the ivory of commerce. It is said that Siberian ivory constitutes the principal material on which the Russian ivory-turner works. Alaska also affords considerable supplies.

Strange as it may seem, the mammoth, whose congener, the elephant, is remarkably sensitive to cold, once abounded throughout the arctic latitudes of the two worlds. More than a hundred years ago not only their ivory but their carcasses were known to exist in Siberia, imbedded in solid ice. The first discovery was on the borders of the Alaseia river, which flows into the Arctic ocean beyond Indigirska. The body was still standing erect, and was almost perfect. The skin remained in place, and the hair and fur were still attached in spots. In 1772 the body of a perfect two-horned rhinoceros, covered with hair, was found preserved in frozen gravel near the Vilhoui or Wiljui, a tributary of the Lena, in latitude 64°. The head and feet of this animal,—also related to tropical species,—are preserved in St. Petersburg. The most celebrated discovery was made in 1799. A Tungusian fisherman named Schumachoff was exploring along the coast of the frozen ocean for ivory. He was near the mouth of the Lena river, in latitude 70°, when he noticed, in a huge block of clear glacier ice, a dark object imbedded too deeply to permit a half savage curiosity to feel tempted to explore. In 1801 the melting of the ice had exposed a portion of the very carcass of the animal whose ivory was strewed along those frozen shores. In 1803 it had become completely disengaged by the dissolution of the ice. In 1804 the Tungusian cut the Tusks, weighing 300 pounds, from the head, and disposed of them for fifty roubles to an ivory merchant. In 1806 Mr. Adams, who was collecting for the Imperial Museum at St. Petersburg, found the carcass still on the shore, but greatly mutilated. It appeared that the Yakutski had actually regaled their dogs upon the flesh; and bears, wolves, wolverines and foxes had gladly feasted upon it! Fresh elephant steaks preserved ten thousand years in Nature's unequaled refrigerator! Thus this priceless relic of a prehistoric world was allowed to waste away. But it was not completely lost to science; for, except one foreleg, the skeleton remained perfect. A large part of the skin had also escaped destruction, together with one of the ears, which still preserved its characteristic tuft of hairs. The skin was of a dark tint, and was covered with reddish wool an inch in length, interspersed with reddish-brown hairs four inches long, and sparser black bristles twelve to sixteen inches long. Dampness, however, had destroyed large portions, and others had been trodden into the earth by bears. Everything of value was now collected, including more than thirty pounds of fur; the tusks were repurchased, and the whole was transported to St. Petersburg, where the mounted skeleton at present stands, in the Imperial Museum,—the skin still remaining attached to the head and feet. This individual was nine feet high and sixteen feet long, exclusive of the tusks. Some portions of the skin and hair were sent by Mr. Adams to Sir Joseph Banks, and they may now be seen in the Museum of the Royal College of Surgeons, in London.

Other discoveries have been made more recently. In 1843 a mammoth was found by Middendorf, a Russian naturalist, on the Tas, between the Obi and the Yenesei, in latitude 66° 30′, in so perfect a state that the bulb of the eye is still preserved in the museum at Moscow. Another carcass, together with a smaller individual, was discovered the same year, imbedded in clay and sand, near the river Taimyr, as far north as latitude 75° 15′.

These sources of information have been fully utilized in the restoration of which a view is given above. This Stuttgart-Rochester restoration may therefore be regarded as embodying, for scientific and popular inspection, all that has been learned in a hundred years, and recorded in a hundred volumes, concerning the external aspect of the primeval mammoth or his American relative.

It is the extinct Siberian elephant which has given us the word "mammoth." It comes from the Russian *mamant*, a name applied by the native tribes to a huge beast supposed to burrow underground, and to perish whenever by chance it becomes exposed to the light. Some, however, think it is derived from the Hebrew *behemoth*.

It is impossible to refrain from speculating on the nature of the events which resulted in the burial of entire mammoths in glacier-ice. That the climate in which they had lived was not tropical, like that of Africa or India, may be regarded as proved by the presence of the fur in which these animals were clothed. That it was not similar to the existing climate of northern Siberia is apparent from the consideration that such a climate would not yield the requisite supply of vegetation to sustain their existence. More especially would forest vegetation be wanting, which seems to have been designed as the main reliance for proboscidians. Northern Siberia must, therefore, have possessed a temperate climate. If the change to an arctic climate had been gradual, the herds of mammoths would probably have slowly migrated southward; or, if no actual migration occurred, the extinction of the mammoth population would have been distributed over many years, and the destruction of individuals would have taken place at temperatures which were still insufficiently rigorous to preserve their carcasses for a hundred ages. Whole herds of mammoths must have been overwhelmed by a sudden invasion of arctic weather. Some secular change produced an unprecedented precipitation of snow. We may imagine elephantine communities huddled together in the sheltering valleys and in the deep defiles of the rivers, where, on previous occasions, they had found that protection which carried them safely through wintry storms. But now, the snow-fall found no pause. Like cattle overwhelmed in the gorges of Montana, the mammoths were rapidly buried. By precipitation and by drifting, fifty feet of snow, perhaps, accumulated above them. They must perish; and with the sudden change in the climate, their shroud of snow would remain wrapped about them through all the mildness of the ensuing summer. The fleecy snow would become granular; it would be *névé* or *firn*, as in the glacier sources of the Alps. It would finally become solid ice,—compact, clear and sea-green in its limpid depths. It would be a glacier; and so it would travel down the gorges, down the valleys toward the frozen ocean, sweeping buried mammoths bodily in its resistless stream. Thus, in the course of ages, their mummied forms would reach a latitude more northern than that in which they had been inhumed. It may even have been the case that living mammoths lingered in the country which had witnessed the snowy burial of herds of their fellows. Some must have escaped the first great snow-deluge, and there must have been a return of sunny days, during which they could seek to resuscitate their famished bodies; and spring must have come back at last, and another hope-inspiring summer,—cheering, but short and illusory. And if a secular pause in the severity of the climate ensued, a few survivors may have lingered for many years. But winter, dire and permanent, was on the march, and the record which it has left declares that the mammoth population struggled in vain against the despotism of frost, and that the empire which was set up has crumbled only under the attacks of many thousand summers.

There has been a time in the history of the Aryan family of men when they seem to have suffered from a sudden change of climate which compelled them to migrate southward. When we trace the movements of the European nations backward, we find, in the remote past, a point of divergence from the nations which crossed the

Hindu-Kush into the peninsula of India. In Central Asia the ancestors of the Hindus, Iranians and Europeans were one people. There arose the Brahmanic and Zoroastrian religions. But the sacred books of the latter contain allusions to a remoter time, when the ancestors of the Aryans dwelt in a country blessed with seven months of summer. This was Aryana-Vaêjo, a land of delight, given by Ahura-Mazda, and supposed to have been located in Southern Turkestan, upon the Plateau of Pamir, or somewhat farther east in the beautiful valley of Cashgar. But lest this paradise should tempt all nations to crowd in and overpopulate it, the "evil being, Angra-Mainyus (Ahriman), full of death, created a mighty serpent, and winter, the work of the Devas." Now ten months of frost prevailed, succeeded by only two months of summer. Of this transformed region, the *Vendidad* says: "There is the heart of winter; there all around falls deep snow; there is the worst of evils." So the ancestors of the Zoroastrians migrated from Aryana-Vaêjo, or Old Iran, southward into New Iran within the modern Afghanistan.*

The *Vendidad*, indeed, seems to contain reminiscences of remoter migrations, stretching from the Caucasus to the "Five Rivers," or Punjab, interrupted by fourteen different stations or pauses, like those of the Israelites through the wilderness which separated them from their "land of promise."

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* Is there no analogy between the Aryana-Vaêjo of the Zend-Avesta and the Eden of the Hebrew sacred books? In both, the primitive home of the white race was a country of spontaneous productiveness and a delightful climate. Both lands were given by a beneficent Deity for human occupation. From both lands our ancestors were driven through the machinations of the Evil One. In both narratives the power of evil is personified in a serpent. The consequence in both narratives is the necessity of resort to cultivation of the soil for the production of bread. May both narratives be pictures reproducing from national memory the same encroachment of physical severities upon the same land of edenic delights?

Geological evidences of a great and somewhat sudden change of climate throughout the North Temperate Zone, in times geologically recent, are too familiar to require more than a mere mention. The greater part of Europe, and all America, to the latitude of 36°, were once buried beneath sheets of glacier ice. In Europe we have the evidence of the presence of man while the continental glaciers were flooding the rivers of France by their rapid dissolution. At the same time the mammoth was there. While thousands of his fellow-mammoths were lying frozen and stark in the icy cemeteries of the North, a few of the giants of a former age had chanced to dwell in latitudes which perpetual snow had not invaded. These were a part of the game which the primeval inhabitants of Europe pursued. Of his ivory they made handles for their implements and weapons. On his ivory they etched figures of the maned and shaggy proboscidian, of which neither history nor tradition has preserved the memory.* The bones and teeth of the mammoth are strewed through all the cavern homes and sequestered haunts of the oldest tribes who hunted and fought upon the plains and along the valleys of Europe.

The reader will irresistibly inquire: "How many years have elapsed since Siberian elephants were encased in ice? How many since their survivors thundered through the forests of England and Central Europe before the chase of the human hunter?" To answer these questions we must ascertain the remoteness of the epochs of continental glaciation, and of the disappearance of the continental glaciers. These are unsolved problems in science. If continental glaciation was caused by a state of maximum eccentricity in the earth's orbit, as Mr. Croll maintains, the last secular midwinter probably occurred about 80,000 years ago, and the Siberian carcasses have lain preserved for eighty or a hundred thousand years; and the decline of the glaciers which witnessed the presence of (Mongoloid?) man in Europe was probably not later than 50,000 years ago.* If continental glaciation was caused by the precession of the equinoxes, as M. Adhémar contends, the last geological midwinter may have been about 10,500 years ago, and the pluvial condition of Europe was somewhat less remote. Regardless of these theories, the present writer is of the opinion that the geological events which have taken place since the epoch of general glaciation do not demand over ten thousand years; and he inclines to think that the pluvial epoch of Western Europe may correspond with those cataclysms of Europe and Western Asia known as the deluges of Ogyges, Deucalion, Noah, and perhaps of the Great Yu in China.†

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* The entire absence of such tradition from Europe, so far as known, seems to imply that the present race exterminated or expelled their predecessors, instead of becoming consolidated with them, as has been sometimes conjectnred. The Indians of America, on the contrary, retained some tradition of the elephant and mastodon. In view of the supposition that the Finns and Lapps represent the premediterranean population of Europe, it would be extremely interesting to know if they retain any national recollections of the hairy mammoth.

Only two species of elephants have survived to our day. These are the African and the Indian (*Elephas Africanus* and *Elephas Indicus*). The former is distinguished by the rounded skull, the immense ears and the lozenge-shaped figure presented by the outcropping plates on the crowns of the molar teeth (see cut). The Indian elephant has an elongated or pyramidally elevated skull, small ears, and narrow, elongated figures, inclosed by the plates of the molars. Both species possess five toes on each foot, but the Indian has only four hoofs behind, and the African three behind and four anteriorly. The mammoth was larger than either. It differed from both in the possession of a dense clothing of hair. It resembled the African species in the size of its tusks, and the Indian in the figure of the vertical plates of the grinders, and its smaller ears. The tusks, however, were larger, more widely spread, and more extensively curved, than those of any living elephant, and their enormous sockets produced a marked elongation of the head. The occiput was largely developed, and the forehead was concave and nearly vertical.

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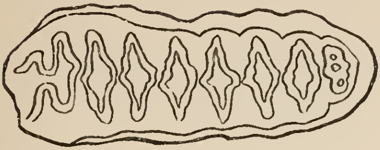
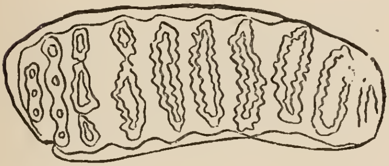
* An exposition of Croll's glacial theory will be found in chapter vii, p. 186.

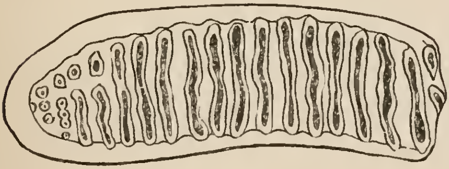
† See more particularly in chapter vi, p. 158 *seq.*



GRINDER OF THE AFRICAN ELEPHANT. PLAN OF ENAMEL-PLATES ON THE CROWN.

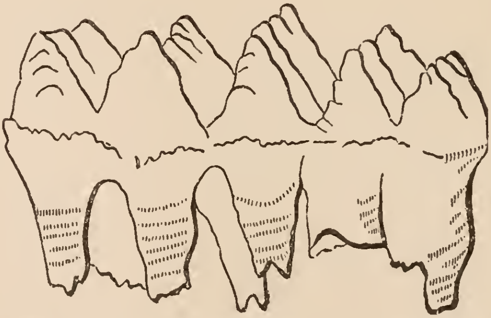


GRINDER OF INDIAN ELEPHANT. PLAN OF ENAMEL-PLATES ON THE CROWN.



GRINDER OF MAMMOTH. PLAN OF ENAMEL-PLATES ON THE CROWN.

The mammoth must not be confounded with the mastodon. The size and general aspect of the latter were extremely similar, though we have no evidence that it was clothed with hair save the discovery of a few dunbrown tufts, two to seven inches long, in connection with the Shawangunk skeleton. The entire structure was truly elephantine, and it lived as a contemporary of the mammoth. Peculiarities of the grinding teeth, however, led Cuvier to establish a distinct genus for its reception. The molar or grinding tooth of the elephant, in its usual condition, consists of a group of hollow, flattened cylinders of enamel-covered dentine, standing vertical to the grinding surface, and arranged in a rather close series, extending from the front to the back of the molar, and all cemented in one huge mass by a substance called cementum (see Figures, page 249). Each flattened cylinder, while unworn on the crown, is closed up, but by wearing it soon becomes open. The cylinders, moreover, ultimately coalesce at the base of the crown, forming a common body from which the roots proceed. Now, in the mastodon (see cut) the vertical flattened cylinders begin to develop on the crown in a similar way; but they are fewer, smaller and less compressed, and coalesce with each other much nearer the surface of the crown. Hence no *cementum* is required to hold them together, and this substance is scarcely discoverable except upon the roots of the tooth.



GRINDER OF MASTODON. PERSPECTIVE VIEW FROM THE SIDE.

Moreover, the mastodont molar is smaller, and eight of them may be fully in use at one time, while in the elephant but four. It is an exceptional circumstance that the succession of molars in both genera is from behind, save that in the mastodon the first two molars are succeeded vertically, according to the law of other mammals.

The great mastodon which once roamed over North America is known as the American mastodon (*Mastodon Americanus*). It seems to have been the dominant proboscidian of the New World in the same age when the primitive mammoth was dominant in the Old World. Yet another species of mammoth roamed here at the same time as another species of mastodon (*Mastodon angustidens*, the narrow-toothed mastodon) roamed in Europe. Evidence exists that the American mastodon continued in America to as late a date as the primeval mammoth in Europe, and was, like that, contemporary with the human species. Barton and Kalm both give accounts of discoveries in which some outline of the soft parts of the animal was still preserved. The Indians, moreover, retained very positive and vivid traditions of the mastodon, calling it "the bison's grandfather," and related that they had all been slain by the Great Man because they were destroying the Indians' game. The skeletons of the mastodon are found sometimes standing erect in beds of peat, marl or mud; and the writer has observed a skeleton, in one instance, within eighteen inches of the surface, where it would seem it might have been deposited within five hundred years. These remains, like those of the Siberian mammoth, occur under such circumstances as to constrain us to believe that their inhumation has been geologically very recent. And yet it seems probable that the primeval mammoths, which were contemporary with the oldest men in Europe, were the survivors of those encased in Siberian ice.

I must now allude to some facts of extraordinary interest. There were once living in India, but before the period of the primeval mammoth, proboscidians which were intermediate between the mastodon and the elephant in the structure of their grinders. We know a gradation of at least four connecting links. First, there was the wide-toothed mastodon (*Mastodon latidens*), which had the ridges across the crown (corresponding to the unworn, flattened cylinders of the elephant), more numerous than in the American mastodon, less distant, more tuberculated, with the intervals between them deeper. Secondly, there was the elephantoid mastodon (*Mastodon elephantoides*), which had a molar twelve inches long, with ten transverse ridges; in both respects resembling the elephant, but still, unlike the elephant, having very little *cementum* between the ridges. Thirdly, there was the flat-faced elephant (*Elephas planifrons*), which, though styled an elephant, and having a supply of *cementum* between the transverse plates, was nevertheless mastodon-like in the shallowness of the clefts between the plates. Fourthly, there was the Hysudric elephant (*Elephas Hysudricus*), in which the divergence from the mastodon type was carried still farther. But lastly, it is carried farthest of all in the living Indian elephant, which has the most complex molars found among existing animals. Now all these proboscidians, together with the primeval mammoth, dwelt in successive periods upon the same continent; and it is a fair inquiry whether they were genealogically related to each other. Venturing to arrange them in a linear series, we should have a succession somewhat as follows: (1) *Mastodon angustidens;* (2) *Mastodon latidens;* (3) *Mastodon elephantoides;* (4) *Elephas planifrons;* (5) *Elephas Africanus;* (6) *Elephas Hysudricus;* (7) *Elephas Indicus.* This at least represents the order of divergence of the molar from the mastodont type, and this is the historical order of existence of the species now extinct. The African elephant thus seems to be a survivor of times as remote as those in which the Hysudric elephant flourished, and its remains have been actually discovered in the Newer Pliocene deposits of the island of Sicily, in association with those of another elephant (*Elephas antiquus*), which came down from the preceding epoch. Here we have a successional order and a parallel structural relationship exactly like those which have been traced in the geological history of the horse-type, though not by any means extending over a geological interval of equal length.

The mastodon preceded the elephant in both the Old World and the New; and this is in accordance with their respective degrees of divergence from still older mammals. In North America the mastodon is known both in the Older and Newer Pliocene. In Europe it made its first appearance at an epoch generally placed, but perhaps erroneously, a little earlier, *Mastodon longirostris* and *Mastodon tapiroides* being referred to the Miocene or Middle Tertiary. As the mastodon, on the one side, graduates into the succession of elephants, on the other, one of the oldest mastodons of Europe (*M. tapiroides*) reveals affinities with the more ancient types of tapir and dinotherium; and the oldest mastodons of America were associated with, or immediately preceded by, other enormous, many-hoofed quadrupeds, so far resembling the mastodon that authorities are divided on the question whether they do not really belong to proboscidians. All these facts accord with the theory of a genealogical descent from the older types, through the mastodons and transitional mastodons to the most divergent elephants.

The Wardian restoration, therefore, carries our thoughts backward directly to the epoch when Europe and America became wrapped in a permanent mantle of snow; and to a later epoch, when it was the companion of the rude ancestors of our species; and then, by association, backward into more distant ages, when the plastic influence of time was slowly evolving the elephantine type from the mastodon and from still older and stranger forms. In these prehuman ages the fair surface of our states and territories was populated by herds of quadrupeds as strange as they were gigantic. They grazed and browsed over regions which are now the sites of waving crops and populous cities, and probably of navigable lakes. Here were nursed the primeval horses, and rhinoceroses, and tapirs, and camels, and pigs, and deer, and perhaps mastodons, whose descendants wandered by the northwest passage to Asia, Europe, and Africa. Here was the real Old World spread continent-wide and populous, while Europe was merely an archipelago. The relics of that wonderful extinct population have been studied by Leidy, and Cope, and Marsh; and through their labors we are permitted to live, as it were, a million years ago. Still more real and present appear the scenes of those primitive times when we stand in the midst of the restored and rehabilitated creatures of the Occident and the Orient which Professor Ward has spread before the eyes of the curious and inquiring in his vast museum at Rochester.

SALT ENTERPRISE IN MICHIGAN.

HAVING had occasion recently to draw up a statement of my connection with the establishment of existing conceptions respecting the geology of salt and brine in the State of Michigan, I was first led to realize that some obligation might rest on me to leave on record, from personal experience and knowledge, a chapter on the historical development of these conceptions. The salt manufacture in Michigan has, in twenty years, attained proportions which are truly enormous. Every fact connected with the record of such a development possesses a permanent interest. The magnitude of the salt business in the state, and the large number of persons connected with it, either in production or consumption, create a wide-spread *popular* interest; while the geological position, attitude and productiveness of three separate salt-producing formations give the subject also an unusual degree of *scientific* interest.

The existence of salt springs at numberless points in the lower peninsula of Michigan has been known from its earliest settlement; and here, as in other states, the Indians, no less than the elk and the deer, supplied their wants from the natural salines. Numerous reservations of lands supposed to contain salt springs had, at an early day, been made by the United States; and several unsuccessful attempts had been instituted by individuals to manufacture salt. Michigan became a state in 1835, and in 1836 seventy-two sections of salt-spring lands were patented to the state by the general government.* A geological survey of the state was instituted by act of the legislature, approved February 23, 1837. Douglass Houghton, M.D., was appointed State Geologist, and his first report was dated January 22, 1838.† One of the first objects contemplated by the legislature which organized the survey, as well as by the superintendent himself, was the determination of precise facts in reference to the value and distribution of the salt springs of the state. Accordingly, about two-thirds of the State Geologist's First Annual Report was devoted to an exposition of the results of his observations upon the brine springs of the state, made during the previous year. He found the salines of the state distributed in five groups: first, those upon the Grand River, near Grand Rapids; second, those on Maple River, in Gratiot county; third, those on the Tittabawassee, in Midland county; fourth, those of Macomb county; fifth, those on the Saline River, in Washtenaw county. No saline indications of importance were known south of a line drawn from Monroe to Grand Rapids. Dr. Houghton gave analyses of twenty samples of brine from as many different localities within the peninsula. These localities were generally on marshes, circumstanced similarly to the salines of New York, or on the immediate banks of streams subject more or less to overflow. As the result of the observations of this year, Dr. Houghton advanced the opinion that the brine supplied at the surface, at any of the localities examined, would prove too weak and too limited in quantity to justify the expectation of remunerative manufacture. At the same time, he announced "a general resemblance between the geology of the valley of the Ohio and that of Michigan," and stated his belief that "the rock formations of our saliferous district are somewhat lower in the series than those occurring in the principal salines on the Ohio," and from this "inferred that the salt-bearing rock would be nearer the surface here" than in Ohio. The similarity of circumstances, as he erroneously conceived, attending the occurrence of brine springs in Michigan and Ohio, led him to advance the opinion that in this state, as well as Ohio, success might follow the boring of artesian wells in the vicinity of the salines.

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* *Act of Congress*, June 23, 1836.

† *House Documents*, pp. 276–316.

This report led to the passage of an act approved March 24, 1838, "To provide for the improvement of certain State Salt Springs," directing the State Geologist to proceed to make explorations by boring at one or more of the springs, and appropriating three thousand dollars to defray expenses.

It marks the intelligent and liberal spirit of the early statesmen of Michigan to note that, by an act approved March 23, 1838, the first organization of the Geological Survey was abolished and an enlarged organization adopted. This established four departments: 1. Geological and Mineralogical; 2. Zoölogical; 3. Botanical; 4. Topographical. Twelve thousand dollars were appropriated for each year between March 1, 1838, and March 1, 1841.*

On the 1st of January, 1839, the State Geologist reported that he had visited the various salines of Pennsylvania, Virginia and Ohio, with the view of collecting information to guide his procedure, and had commenced the sinking of two *shafts*,—one on the Tittabawassee near the mouth of Salt River, and the other on the Grand River, about three miles west of Grand Rapids. Before the close of the month the legislature made further special provision for the prosecution of these two enterprises. The work, however, was conducted under great difficulties. The surface materials were first penetrated on the Tittabawassee, by a shaft eight feet square, to the depth of forty-five feet, when fresh and brackish water overpowered the pumps, and an attempt was made to sink a drill at a neighboring point. From May to November, 1841, the drill penetrated but 139 feet, when a rock was struck (supposed by Dr. Houghton to be quartzite) which the drill entered but half an inch in eleven hours, though loaded with a weight of 270 pounds. At this obstacle the work was abandoned.

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* When, in 1859, the legislature of the state determined to establish a new Geological Survey, they adopted the law of 1837, instead of that of 1838, and appropriated five thousand dollars for the expenses of two years.

The well near Grand Rapids (Sec. 3, T. 6 N, 12 W.) was begun in July 1838, and ended in 1842, at a depth of 473 feet. It was afterward carried to a depth of 876 feet, and somewhat beyond.* This well passed 40 feet through superficial materials; 21 feet through the Michigan Salt Group; 280 feet through the Marshall Group, from which a weak brine flowed copiously; and 535 feet through the Huron Group.†

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* According to information furnished by John Ball, Esq., of Grand Rapids, December 22, 1862. It was bored by Hon. Lucius Lyon, under contract with Dr. Houghton, for the State. Mr. Ball himself made the measurements of depth, and payments accordingly, while Dr. Houghton was engaged in the Lake Superior region. "The last measurement was 876 feet, and they bored a short time after, and got jammed, as they express it, and gave it up."

† These determinations and designations are of later date, and made by the present writer.

In these two costly and protracted experiments no brine was obtained materially better than that previously occurring at the surface.

In the meantime, in January 1840, Mr. Lyon began boring for salt on his own account. His location was near Bridge-street bridge, in the village (now city) of Grand Rapids, and by July 1841, he had penetrated to a depth of 661 feet. This well began upon the Carboniferous Limestone, which was found 19 feet thick, and passed 171 feet through the Michigan Salt Group, 253 feet through the Marshall Group, and 214 feet into the Huron Group. It furnished an enormous flow of brackish water, amounting to one hogshead per minute; and by means of an ingenious contrivance brine was brought up unmixed with the flow of fresh water, which proved to be one-fifth saturated,— or at least equal in strength to brine at that time used on the Kanawha and Ohio rivers. With salt selling at three dollars per barrel, Mr. Lyon was enabled to manufacture a limited amount without loss. The want of brine of adequate strength, however, led to an early suspension of the business.

After the failures of 1838–42, the "Salt Spring Lands" came into the market as little superior to ordinary agricultural lands. In 1849 (March 28), on the organization of the State Normal School, twenty-five sections were set apart for the creation of a Normal School Fund, at the minimum price of four dollars an acre for the unimproved tracts; and in 1855 (February 12) twenty-two sections were set apart for the endowment of an Agricultural College.

A lingering belief yet survived, however, that Michigan was still destined to become a salt-producing state;

and citizens of Grand Rapids, still remembering how near to the verge of success Mr. Lyon had reached, seriously agitated the resumption of explorations. Through the personal exertions of Dr. George A. Lathrop, of East Saginaw, and James Scribner, Esq., and others, of Grand Rapids, a law was passed, which was approved February 15, 1859, offering a premium of ten cents a bushel for all salt made from brine obtained by boring within the state, and exemption from taxation of all property employed in the manufacture,—the bounty to be paid when not less than 5,000 bushels should have been manufactured. On the same date an act was approved for the completion of the geological survey of the state; and on the 9th of March the present writer was commissioned by Gov. Moses Wisner to conduct the survey. As soon as the season permitted he began an examination of the outcropping rocks in southern Michigan. His principal work this season extended from the Detroit River across the southern portion of the state, and north to Newaygo county. These observations, together with those reported by an assistant from Genesee and Saginaw counties, and some less systematic original studies in Shiawassee, Genesee and Saginaw, furnished the data on which it was concluded that the formations of the peninsula presented the arrangement of a nest of wooden dishes. The most important determination was the identification of an additional group of rocks, not hitherto noted in the state or elsewhere in the United States. This was intercalated between the limestone, then first ascertained to be the great Carboniferous Limestone of the United States, and the ferruginous sandstones which outcrop extensively in the southern counties. It was designated provisionally at that time the "Gypseous

Series"; but a little later, the "Michigan Salt Group." It has a thickness of 180 feet, and consists of argillaceous shales, clays, magnesian limestones and beds of gypsum.* Here is the origin of the brine which escapes in a circle of springs marking the contour of the formation. This group of strata underlies 17,000 square miles in the central portion of the state. It is dish-shaped, and constitutes an immense reservoir or saliferous basin. The edges are sufficiently elevated to prevent the efflux of water which finds its way into it; and hence the saline particles have never been washed away, as would have been the case if the formation possessed any continuous dip from border to border, or even had a depression on one side sufficiently deep to drain its contents. Beneath this series of shales is a porous sandstone—the Napoleon sandstone of the Marshall Group—which, within the circumference of the basin which it forms, becomes saturated with brine from above. From the nature of the case, it is evident that the strongest brine must accumulate in the deepest part of this basin.

In April, 1859, an artesian boring for salt was begun at East Saginaw, under the direction of Dr. G. A. Lathrop. I am not informed of the geological reasoning which led to the selection of that location. There were no brine springs in that vicinity, nor were there any outcrops of the underlying rocks. The result showed that the rocks were buried a hundred feet deep. Dr. Lathrop had traveled extensively in the regions about Saginaw Bay, and possessed a large amount of exact information on the geology of that part of the state. At Bay City, moreover,

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* Without doubt these strata correspond to rocks which, in other states, constitute some of the lower part of the great Carboniferous Limestone series.

Mr. James Frazier had found brine by sinking a common well to the depth of eighty feet; and a similar result had been reached at Bangor.

On the 12th of August, 1859, a well was begun at Grand Rapids by the "Grand Rapids Salt Manufacturing Company," under the direction of James Scribner, and this was completed October 14 to the depth of 258 feet, with brine not exceeding 20° in strength. The impelling motive for this location was the traditional belief that the springs of that vicinity issued through fissures from a deep-seated supply. In October, 1859, I visited Grand Rapids, after completing the tour just indicated, and first declared, through the public prints of the city, that the salt springs of that vicinity were supplied by an overflow at the *margin* of the "salt basin" which lay eastward from that point; and hence all expenditures at Grand Rapids must prove comparatively unproductive. I stated on that occasion that the configuration of the strata pointed to the Saginaw valley as the position of the principal synclinal, and added that the very presence of the Saginaw bay and river indicated that region as overlying the deepest depression of our formations. Meantime, however, other wells were begun by the "Grand River Salt Company" and by Mr. R. E. Butterworth, but they led to no satisfactory results. The same must be said of three other wells bored at a still later date, all of which reached over 400 feet.*

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* On the very day on which these words are penned, I have received information of a similar demonstration of the wisdom of heeding scientific advice. Some years ago I was commissioned by Governor Austin, of Minnesota, to make a survey for salt in the vicinity of Belle Plaine on the Minnesota river. A land bounty had been offered for defrayment of expense of boring, in case competent geological authority should approve the venture. Though my report to the Governor was unfavorable, I have been informed that the company

In November, 1859, I paid Saginaw and vicinity a geological visit. The East Saginaw well was then (November 10) down 445 feet, and Dr. Lathrop submitted to my examination a complete series of rock samples brought up. Comparing these with the rocks already studied at their outcrops on three sides of the peninsula, I perceived that a very satisfactory correspondence existed, and announced that the bottom of the Marshall Sandstones, the reservoir of the brine, would be reached at about 800 feet, and that there would be no need of continuing to a greater depth, unless it were decided to penetrate to the Onondaga salt formation.

In February, 1860, I made further examinations of the geological situation at Grand Rapids. These fully confirmed former conclusions. There was furnished at this time, by A. O. Currier, a detailed list of borings brought up from the Grand River Salt Company's well, then (February 11) 156 feet deep. Mr. R. E. Butterworth's well was 146 feet down, and he supplied me with a register of rocks pierced, subsequent information being added by Mr. Martin Metcalf, to the depth of 490 feet. I gave a public address in Lyceum Hall, on "Salt and its Geological Relations," in which I set forth my conception of the geological situation in Michigan. On returning home I addressed a communication to the superintendent of the Saginaw Salt Works, on "The Salt Borings of Saginaw," with the view of making clear my views, as State Geologist, of the geological conditions and prospects under which his enterprise was conducted. It was published in

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interested persuaded the legislature to make over the grant, when they bored a hole and left it as a record of successful business management. The company never informed me of this procedure,—nor did Governor Austin.

the *Saginaw Enterprise* in February. The East Saginaw salt well was completed February 24. It was 669 feet deep, and yielded brine of 94°. It had reached the solid rock at the depth of 92 feet, and after passing through the coal measures, with their initial and terminal sandstones, pierced the carboniferous limestone, and found the Michigan Salt Group of strata 169 feet thick, and eminently saliferous, though from the compact nature of the formation the brine was very limited in amount. In the Napoleon sandstone beneath, 109 feet thick, the reservoir of the brine was struck which furnished an abundant supply, and was obtained at almost precisely the point which geology had predicted. The well terminated near the middle of the sandstone. On June 12 I again visited the salt works. Preparations were making to bore a second and larger well. This was subsequently carried to 806 feet, extending through the sandstone and penetrating the underlying shale 64 feet. By July, 1860, a "block" had been erected, and boiling commenced. Before the close of the year 4,000 barrels of salt had been manufactured, and four other companies had commenced boring at different points along the river.

During the season of 1860 careful geological explorations were conducted around the Michigan shores of Lake Huron and the islands at the head of the lake. Thus the correct view of the geology of the peninsula was more perfectly defined, and more permanently settled. The most important determination in this connection was the identification of a great development of the gypseous formation of the state in a high ridge which approaches near the lake about four miles south of Tawas. The gypseous series had been traced in the salt-boring at East Saginaw, and here was seen a ridge corresponding to the proper place of outcrop of the formation, immediately below the carboniferous limestone seen at Point au Grès. There had been a strolling explorer in the vicinity in search of lead, copper, coal, and anything else whatever in the mineralogical series, — he seemed to have no idea of the orderly arrangement of things, — and he had already bored in this ridge. This "Professor" found nothing which seemed to reward his efforts, but I discovered among the débris left by him some small fragments which I at once identified as belonging to the gypseous series. This entirely confirmed the induction already reached. When Mr. C. H. Whittemore, of Tawas, assured me that several fruitless explorations had been made in the ridge, I assured him, in return, that *there* was the place for the great gypsum formation of the state. Indications of the outcrop of the formation had already been detected on the east side of Saginaw Bay, near the mouth of Pigeon River.

Gypsum had been reported many years before in the bed of the lake off Whitestone Point, but the high wind which prevailed when I was there prevented obtaining a view of it. This point is several miles south of the ridge in which I identified the gypsum formation. "Plaster Point," in the same vicinity, which really presents an exposure of the gypseous formation, with most of the gypsum dissolved out, is also some miles from the proper place of outcrop of the formation, at such elevation above the lake as to afford practicable working.

In November, 1860, a résumé of results of the geological survey was published in the *Detroit Tribune* by Henry Barns, who took an active interest in the work.

In December the Chicago Academy of Sciences made an excursion to the University, and the State Geologist, by request, devoted an hour to an exposition of the results of the geological survey. A report of this lecture was contained in the Chicago papers.

The *First Biennial Report of the Progress of the Geological Survey* was presented to the governor, and by him to the legislature, on the 31st of December 1860. Some later developments connected with the salt interest were added during the printing of the report. The *Detroit Advertiser* published, in January 1861, a copious résumé of the results, and the *Tribune* published, during the same month, very extended extracts, including everything relating to the production of salt. An advance copy of the geological portion of the report was sent to the *American Journal of Science*, August 14, and was noticed in September. The complete report was distributed between November 16 and November 30, 1861.

In this report the following estimate was recorded of the importance of the salt interest, then just emerging into notice: "If the geological indications on which I found my opinions are not fallacious, we have the most magnificent saliferous basin upon the continent east of the Mississippi" (p. 165). "The vast geographical extent of the salt basin of Michigan, together with the extraordinary strength of the brine, furnish strong reasons to anticipate that at no distant day Michigan will be the leading salt-producing state in the Union" (p. 193). This was said ten months after the success of the first well. In 1880 Michigan produced more salt than any other state in the Union, the official inspectors reporting 2,678,598 barrels.

The outbreak of civil war interfered with the organized prosecution of field work during 1861; but the State Geologist found abundant occupation, an important part of which consisted in the office and laboratory investigation of the materials accumulated during the two preceding years.*

Let us understand now what the researches of 1859–61 succeeded in establishing. They showed that the formations of the lower peninsula of Michigan constitute a series of successively overlying dish-shaped structures, with margins approximately concentric with each other and with the boundaries of the peninsula. The uppermost rock formation occupies nearly the central part of the peninsula, and has less geographical extent than any of the others. This is the Coal Measures, consisting of a sandstone at or near the top, and another named the Parma Sandstone at the bottom. Next below is the Carboniferous Limestone, the outcropping border of which is somewhat farther from the center of the peninsula. Next is the Michigan Salt Group, which actually underlies the whole central part of the peninsula, and outcrops at

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*Some of these scientific results were published as follows: *Notice of the Rocks lying between the Carboniferous Limestone of the Lower Peninsula of Michigan and the Limestones of the Hamilton Group, with Descriptions of some Cephalopods supposed to be new to science*, Amer. Jour. Science, II, xxxiii, 352–366, May 1862; *Salt Manufacture of the Saginaw Valley*, Hunt's Merchants' Magazine, 209–223, Sept. 1862; *On the Saliferous Rocks and Salt Springs of Michigan*, Amer. Jour. Science, II, xxxiv, 307–316, Nov. 1862; *Descriptions of Fossils from the Marshall and Huron Groups of Michigan*, Proc. Acad. Nat. Sci., Philadelphia, 405–430, Sept. 1862; *On the Identification of the Catskill Red Sandstone with the Chemung*, Amer. Jour. Sci. II, xxxv, 61–2, Jan. 1863; *Descriptions of Fossils from the Yellow Sandstones lying beneath the "Burlington Limestone" at Burlington, Iowa*, Proc. Acad. Nat. Sci.. Philadelphia. Jan. 1863. pp 2–25. These articles all related to the formation which serves as the reservoir of the brine supplying the principal wells along the Saginaw River. and were contributions toward fixing its geological age and characteristics. Other investigations were published at later dates.

Grand Rapids on the west, and on the shores of Saginaw Bay on the east, and underlies Washtenaw and Jackson counties on the south. Next, in descending order, comes the Marshall Group, consisting chiefly of sandstones whose outcrops create the most elevated and hilly belt of the whole peninsula. The other formations follow downward as shown in the following table:

I. Upper Carboniferous.	1. Woodville Sandstone.	
	2. Coal Measures proper.	
	3. Parma Sandstone ("Conglomerate").	
II. Lower Carboniferous	1. Carboniferous Limestone.	
	2. Michigan Salt Group.	
	3. Marshall Group.	(*a*) Napoleon Sandstone.
		(*b*) Red Shale
		(*c*) Marshall Sandstone.
III. Devonian	1. Huron Group	(*a*) Portage and Chemung.
		(*b*) Black Shale ("Genesee").
	2. Hamilton Group.	
	3. Corniferous Limestone.	
IV. Upper Silurian	1. Lower Helderberg or Water Limestone.	
	2. Salina Group.	
	3. Niagara Limestone.	

This definite exhibit of the geological succession in the lower peninsula had never been made before. The Carboniferous Limestone had never before been identified in the state, but had been generally confounded with the Monroe and Mackinac limestones. The Michigan Salt Group was a totally new and previously unsuspected formation. It is repeated in no other state in the Union, and is known elsewhere only in New Brunswick, Nova Scotia and Cape Breton, where later researches have shown it to possess a still greater development. The fact that the formation underlies all the central part of the state was not only unsuspected, but was a fact out of harmony with the theory then prevailing respecting the origin of gypseous deposits. Geologists generally had held gypsum to be a secondary product, resulting from chemical reactions in the rocks, and especially from the action of sulphuric acid on limestones or dolomites.[*] The conception of a continuous gypsum formation having a sedimentary origin had probably seldom if ever been entertained. That view resulted from the present writer's researches, and at this day scarcely any other finds defenders. Salt basins, therefore, are the sites of ancient areas of salt water which have gradually dried up.[†]

Before these investigations the gypsum of Mackinac and Grand Rapids had been regarded as of the same geological age. It was now shown that the Mackinac gypsum is of the age of that in central New York and on Sandusky Bay. It followed that the whole peninsula is underlaid by a second and deeper salt basin,— the Salina formation, and that quite probably this basin would also be found a source of brine supplies. The report showed that the salt springs of the peninsula follow especially the lines of outcrop of the principal salt basin and mark the geographical boundary of the formation. It showed that the area of the peninsula had never been subjected to disturbing agencies; hence the strata were but little fissured, and few opportunities existed for the ascent of brine from deep underlying formations. It raised the query how brine, which is heavier than water, should be made to ascend several hundred feet through fissures accessible to shallower fresh waters, even if such fissures existed, and showed that of necessity the undiluted brine from any deep-seated formation must be *pumped* up; and that if salt water overflows at an artesian boring, it results simply from a head of *fresh* water mingled with some accidental supply of brine. It showed that the marginal salt springs of the state are simply drippings from the salt-bearing formations, prompted by the descent of fresh waters into them, and greatly diluted by rains falling near the locations of the springs. It showed that the salt springs of Michigan, which had been the object of so much exploration, legislation and expenditure, possess no importance except as "licks" for wild animals, and that the seventy-two sections of "salt spring lands" patented to the state never possessed any value above that of ordinary agricultural lands.*

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[*] See Reports on the Geology of New York. This improbable view is even still held, in reference to the gypsum of central New York. by James D. Dana (*System of Mineralogy*, 614, 639; *Manual of Geology*, 3d. ed., 234.) Without doubt, sulphuric acid may result from the action of oxygen on sulphuretted hydrogen. Without doubt the reaction of sulphuric acid and limestone produces gypsum. But sulphuric acid may also result from the decomposition of gypsum, and, as a fact, native sulphuric acid is not found in any connection with sulphuretted hydrogen except where evidences of the presence of gypsum also exist Moreover, the lenticular masses of gypsum, inclosed in regular beds in the clays of the Salina group, present vastly more the appearance of the relics of a once continuous formation dissolved away than of the products of chemical action in place.

[†] See the writer's *Sketches of Creation*, ch. xxvi.

In July 1862, in consequence of some new facts communicated by Dr. Lathrop, I revisited the Saginaw region, and studied all the new developments. Dr. Lathrop supplied, in addition to previous information, specimens of chips from the "Orange County Company's" well, and Mr. Sutherland furnished borings from the "Ann Arbor and Saginaw Company's" well. I had also the opportunity of consulting a complete register of the "Carrollton Mill Salt Company's" well, and got some information from Davis & Co., of Zilwaukee, and other facts concerning the wells of J. H. Hill, and Paine and Briggs. Combining, now, all the information accumulated to this date, and making careful comparisons and tabulations, I was led to the conclusion that the Bay City wells (Bay City, Clark's, Braddock's and Fitzhugh's), which were much shallower than the wells farther up the river, *found their supplies of brine in the Parma Sandstone, at the base of the Coal Measures.* This added a *third* productive salt basin to the outfit of the peninsula. I had indeed stated in my official Report, that "Brine is found issuing at the outcrops of the Coal Measures, the Gypseous Group, the Napoleon Group, the Marshall Group, and the Onondaga Salt Group (p. 165). I had also stated (pp. 97, 152) that brine of 14° strength had been obtained at the bottom of the Coal Measures. But it was now shown that the Parma Sandstone at the base of the Coal Measures is actually a productive brine reservoir supplied from the Coal Measures, as the sandstones of the Marshall Group constitute a brine reservoir supplied from the Michigan Salt Group. A paper was drawn up giving an exposition of the new views, and published in the *Saginaw Courier*, in the latter part of July 1862. It was stated, as an inference from the new determination, that Dr. Fitzhugh, in the well at Bay City, then in process of boring, "ought to strike the Napoleon Sandstone at 996 feet, and the Red Shale at 1,105 feet. "These distances," it was added, "may be lessened to the extent of 30 feet," in consequence of some indications of an error in the records of the well, as kept by the person in charge. The subsequent result showed that the Napoleon Sandstone was struck (in consequence of a great thinning of Michigan

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*Most of these points were brought out in the Report submitted December 31, 1860, and printed in 1861. See especially pp. 165–6.

Salt Group) at 916 feet; but the brine obtained at this point possessed 96° of strength.*

A subsequent year witnessed another confirmation of what had been only a geological inference. I had all along pointed out the existence of the Onondaga Salt Group underneath the peninsula, and expressed the belief that it must prove more productive than in central New York. I advised the enterprise of boring into that formation to test its productiveness; but it was only when the Port Austin well became a success that the theory received its verification. Rock salt was subsequently discovered at Alpena, and at Goderich in Ontario, where it has become an important article of commerce. Still later experiments have developed an excellent supply of brine at Manistee, and also at Muskegon.

The geological inference of gypsum in the ridge south of Tawas has been also fully confirmed. During the war, a gentleman wrote to me for an indication of favorable localities for speculative explorations. I directed him to the ridge in question. An inexpensive boring determined the existence of a heavy bed of gypsum. He took a claim, as I have been informed, in exchange for an old rifle. After a little excavation the gypsum was fully exposed, and he sold his claim for a large sum of money.†

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* This discovery was embodied in the articles written this year (1862) for the *Merchants' Magazine* and the *Amer. Jour. of Science*. It has been shown by later artesian borings that all the formations of the peninsula are somewhat saliferous, while in the Huron Group, those substances known as "bitterns" exist in predominating abundance, and give origin to the celebrated "mineral wells" of Michigan.

† It is of course necessary to say that the speculator neglected several things. He never compensated the author of his good fortune. He never thanked him for the advice. He never even reported to him the result. He did not even inform the purchasers of his claim who had guided him to the discovery. Finally, the present owners of the quarry, it is to be supposed, are not oppressed with anxiety over the toil and study which guided to the development of the valuable property.

The gypsum business at that point grew into an industry of large importance.

I proceed now, from a sense of duty to the interests of truth, to make some statements aimed at a certain little popular delusion. Soon after the successful issue of the salt enterprise in the Saginaw valley, certain ancient wiseacres gave it out that Dr. Houghton had always held the Saginaw valley to be the center of the salt basin of the peninsula. They had been personally intimate with Dr. Houghton. He was the original discoverer of the existence of salt underneath the valley. So they dwelt on the far-seeing sagacity of Dr. Houghton, and dilated on the interest of the delayed fulfillment of his predictions. The pseudo-tradition went into the newspapers. Then it was copied into the pamphlet histories of salt development. Then it outcropped in official reports, and went on record from the pens of men who only knew that such claims were afloat.

Now Dr. Houghton was a man of superior scientific sagacity and attainments. He held an honorable position among the scientific men of his time. His name reflects luster upon the history of the state. Moreover, he was industrious. He was abundant in feasible and plausible projects. He had a wise tact in the management of men, and in gaining success. He never seemed to give utterance to all he knew. He left the impression that he held an immense reserve of knowledge, which his interviewer was at liberty to magnify according to fancy. It was undoubtedly a prudent spirit which restrained precipitancy in the enunciation of opinions or conjectures, and kept his counsels to himself until completely prepared to put them into execution. It left every person at liberty to attribute to Dr. Houghton very much more than he ever directly expressed, and gave his methods an air of mystery which really set imaginations to work. But, in fact, he was chiefly bent on enterprises which had an economical outlook; though in the upper peninsula he accomplished a large amount of careful stratigraphical and mineralogical work. It is not to be taken as any disparagement of Dr. Houghton that he had no such conception of the geology of the lower peninsula as would render possible the theory which has been attributed to him.

In the first place, *he had no conception of the existence of any "salt basin" whatever in the peninsula.* He held the opinion that there existed a general strike of the rocks from northeast to southwest. In his Report, 1839 (p. 9), he says: "The line of bearing of the members constituting this group of rocks, not only in the northern but in the southern portion of the peninsula, is regularly northeasterly and southwesterly. * * * My examinations would lead me to infer that the coal of the central portions of our state, and that upon the Illinois River, is embraced in a rock which belongs to the same portion of the great basin [the Mississippi valley]. * * * I am also led to conclude that the portion of the rock series which in Illinois and Wisconsin embraces the ores of lead, is identical with a portion of the rock formation which occurs in the northern part of our own state, — a circumstance which might fairly have been inferred from the general line of bearing of the rock" (p. 10). * * * "A slight glance at the map of our state will sufficiently explain the relation which Saginaw Bay, of Lake Huron, holds to the line of bearing already mentioned. This great arm of that lake stretches in a southwesterly direction, making a deep indentation in the peninsula, and occupying a denuded space in the sandstones just at that point where the latter comes in contact with the limestone of the north" (p. 10). * * * "These hills [the highlands of the Au Sable] follow the line of bearing of the rock formations, and no doubt extend diagonally completely across the state" (p. 6).

These, and numerous similar expressions in his reports, are entirely inconsistent with that dish-shaped conformation which we have found to exist, and inconsistent with any conception of a "salt basin" in the state. The first foreshadowings of any basin arrangement are found in the reports of Mr. C. C. Douglass and Mr. Bela Hubbard, dated January 4 and January 24, 1841. Mr. Douglass remarks that "the same rocks, with one or two exceptions, occur on both sides of the state, having the same geological position; also, they have very nearly parallel and uniform positions" (p. 103). This seems to contemplate the existence of a synclinal trough running north and south across the peninsula. Mr. Hubbard, however, traces the outcrop of the Coal Measure rocks from east to west across the southern part of the peninsula, and thus more distinctly shadows forth the conception of a basin structure (p. 125). He says, moreover, "All the rocks on the eastern slope of the peninsula south of Saginaw Bay have a general dip northwesterly, while the dip along the southerly and westerly border of the basin of coal-bearing rocks is such as to indicate the counties of Clinton and Gratiot as occupying nearly the central part of the coal basin" (p. 137). This, indeed, is a recognition of a basin structure, but it locates its center more than fifty miles southwest of the Saginaw valley. Moreover, this was not Dr. Houghton's, but Mr. Hubbard's, idea. Following Hubbard's suggestion, the basin-structure was represented upon the geological map of the Western States contained in Professor James Hall's Report on the Fourth District of New York, which appeared in 1844.

In the second place, Dr. Houghton had *an erroneous conception of the mode of occurrence of the brine springs of the peninsula.* In his Report, dated January 22, 1838,* after enumerating a large number of salt springs, he says: "We can only hope to obtain a permanent supply of brine of sufficient strength from the springs of our state by sinking shafts through the rocky strata until the salt-bearing rock be reached, be the distance more or less" (p. 297). These shafts were to be sunk at "the points enumerated." Here we see no indications of a salt basin and an origination of salt springs by an overflow at the margin. In his Report dated January 1, 1839,† concerning the improvement of the State Salt Springs, he says: "The brine springs of our state, like those of Ohio, Pennsylvania and Virginia, emanate from a rock which lies deep, being covered with a mass of rock and earthy matter which (in order to procure salt water that can be economically used) it is necessary to penetrate" (p. 39). Speaking of the situation in Virginia, Ohio and Pennsylvania, he says: "The salt rock lies at considerable depth, and is overlayed by strata of sandstone, limestone, slate, etc., and through fissures in these overlying rocks the salt water, much diluted by influx of fresh water, originally rose to the surface (p. 40).

Mr. Bela Hubbard, also, in his Report of 1840, retained the same belief. He says: "By reference to a map of the state, it will be apparent that the strongest brines (among which are included those in the vicinity of these borings) make their appearance along a line which will be found to correspond with the synclinal axis, or axis of the dip of the rocks composing the great peninsula basin, — a circumstance which would be looked for from the fact that the ordinary law of gravitation would conduct the strong brines to the lowest levels of the rock strata" (p. 139). Commenting on the geology of Lucius Lyon's well, at Grand Rapids, he also says: "The brine now obtained at a depth below the above of about 230 feet may be supposed to proceed by veins from the lower salt rock lying at a still greater depth, and from which the strongest and best supplies of brine in our state may be expected to be obtained" (p. 140).

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* *House Documents*, 1838, 276-316.

† *House Documents*, 1839, pp. 39-45.

In the third place, he had *an erroneous conception of the geological succession in the peninsula.* In his special Report on salt springs, dated 1839, he states his plan to be to sink a shaft on the Tittabawassee to the "bed rock." The "salt rock" he supposed "to be at a depth of 500 to 700 feet" from the bottom of the shaft (p. 42). Then, speaking of the well near Grand Rapids, he says: "The amount of rock-boring required will not vary much from that at the Tittabawassee salines" (p. 42). Thus, he supposed both situations to be geologically similar, while, in fact, the location on Grand River was at least 360 feet below the other, and was separated by all the thickness of the coal measures and the carboniferous limestone. With similar inaccuracy he considers that "the rocks of this northern portion of the peninsula may be regarded as referable to the great carboniferous group of the state" (*Report*, Feb. 4, 1839, p. 2). So he is "led to conclude that that portion of the rock series which, in Illinois and Wisconsin, embraces the ores of lead, is identical with a portion of the rock formation which occurs in the northern part of our state" (p. 10). Now, the lead ores referred to are found in the lower silurian, while the Michigan rocks are Hamilton and Corniferous, in the Devonian. It is not pretended that such errors of identification reflect the least discredit upon their author; but, being facts, they show the impossibility of a truthful conception of the geological relations of the brines of the peninsula.

Messrs. Hubbard and Douglass devoted their attention to the lower peninsula, while Dr. Houghton was mostly occupied with the upper peninsula. The assistants, therefore, acquired a more thorough acquaintance with the lower peninsula, and I never look over their reports without a feeling of admiration for the general accuracy attained, in the face of the gigantic difficulties presented by the unsettled and unimproved condition of the country. But these assistants never attained an entirely correct correlation of the formations on the eastern, western and southern slopes of the peninsula.

The first attempt at a systematic general account of the stratification of the peninsula was made in 1840, by Mr. Hubbard.* In this he reached several important conclusions, which, under the authority of certain later geologists, were ignored, but which, with a more thorough acquaintance with Michigan geology, have been admitted as sound. The northern outcrops of the formations of the peninsula were not reported on by him until 1841.† In his attempt to assign them to their proper stratigraphical positions he fell into singular errors, and introduced into the most elaborate account of the peninsula which was destined to be published for twenty years a confusion of facts which rendered the geology of Michigan an enigma to everyone who attempted to parallelize the rocks with those in the surrounding states.* The following is Mr. Hubbard's tabular statement of the succession of groups embraced in the peninsula:

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* *Mich. Geol. Rep.* 1840, p. 87.

† *Mich. Geol. Rep.* 1841, pp. 115, 136.

A. Erratic Block Group, or Diluvium.	
B. Tertiary Clays.	
C. Coal Measures,	I and 2.
D. Sub-carboniferous Sandstones,	II, 3.
E. Clay and Kidney Ironstone Formation,	III, 1.
F. Sandstone, of Point aux Barques,	II, 3.
G. Argillaceous Slates and Flags of Lake Huron,	III, 1.
H. Soft, Light-colored Sandstones,	II, 3.
I. Black, Aluminous Slate,	III, 1, *b*.
K. Limerocks of Lake Erie,	III, 2 and 3.

In this table the numerals affixed at the right indicate the equivalents given in the table of formations as now established (p. 268). It will be seen that Mr. Hubbard's table makes no separate mention of the formation known as the Michigan Salt Group. But, on the contrary, other formations are three times repeated. The groups marked D, F and H are but different outcrops of the Marshall Group (known in Ohio as the Waverley Group); and those marked E, G and I but different outcrops of the Kidney Iron, or Huron Group. Following Dr. Houghton in the report of 1838, Mr. Hubbard regarded the Point aux Barques sandstones and conglomerates as occupying a position beneath the Kidney Iron formation of the southern part of the state, and consequently failed to identify the underlying shales. In the next place, Mr. Hubbard identified with the Point aux Barques shales the shales of the Michigan Salt Group struck in the salt wells at Grand Rapids, although these latter actually occupy a position above the Marshall sandstones. When, therefore, these sandstones and the underlying Huron shales were struck in the boring of the salt wells, they were supposed to constitute the third couplet of similar strata, and are set down as groups H and I in the above table.*

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* See, for instance, Professor James Hall's *Report on the Geol. of the Fourth District of New York*, p. 519. The present writer explained the causes of this confusion in an article in the *Proceedings of the Amer. Phil. Soc.*, xi, 59, 60, March 5, 1869.

It is manifest from these documentary proofs that there were not in existence at the period when Dr. Houghton gave personal attention to the geology of the peninsula, and formed his judgments on the geological relations of the salt springs, any such correct conceptions of the basin-structure of the peninsula, the geological origin of the brine, the mode of occurrence of the brine springs, or the general geological constitution of the peninsula, as rendered possible the belief that the lowest depression of the salt basin (or basins) of the peninsula would be found under the Saginaw valley. Dr. Houghton's procedures in locating the two state artesian salt wells are in accordance with the evidence cited, and are of themselves sufficient to prove that he did *not* entertain the belief ascribed to him. If such beliefs were held, why did he not concentrate his efforts in the Saginaw valley? Why locate one well on the Tittabawassee and the other on the western slope of the peninsula? I have heard one solution of the mystery, which no friend of Dr. Houghton, and indeed no person cognizant of his personal integrity, would feel disposed to urge or to credit. I have heard that one survivor of the period when the "wild cat" was very troublesome in Michigan,—one of the fourteen or fifteen hundred who have claimed that they were associated with Dr. Houghton in his public work,—now asserts that Dr. Houghton privately whispered in his ear that he put the state wells on the Tittabawassee and Grand rivers *for the purpose of diverting attention from the Saginaw*, the real center of the salt formation!

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* *Report*, p. 133.

With profound respect for the real ability of Dr. Houghton, with an unreserved recognition of the importance of his services in the upper peninsula, I feel compelled to record the opinion that the time has arrived for dispelling some of the myths which have lingered about his memory, and for denying, with the proofs, that he had any correct knowledge of the geology of the brines of Michigan, or ever imagined that the most promising region for salt enterprise was located in the Saginaw valley. The existing conception respecting the geology of Michigan brines, on which an immense and widespread industry has been built up, have been originated in later times, and by other investigators. The author regrets, nevertheless, that his own connection with the later developments, and his personal relation to facts and their bearings upon each other, have been such that a correct and adequate exposition of the historical data could not have been offered from some other pen. A full history of the progress of ideas and the succession of projects and enterprises connected with salt development in Michigan, placed on record and published by authority, would constitute a document of deep interest to the people of Michigan, and a record whose value to the general public would increase with every passing decade.

A REMARKABLE MAORI MANUSCRIPT.

THE following remarkable manuscript was discovered by the agent of the Public Parsimony Society of New Zealand in March of last year. There is a cavern, the entrance to which is about eight miles from Mt. Pollux, in Otago, in which the agent was hunting for diamonds to sell to Mesdames Vand Erbuilt and Makké, with a view to paying off the British national debt. In one of the dry and dust-covered clefts of the cavern, about a hundred and thirty-four miles from the entrance, he came upon a roll which, on examination, proved to be covered with characters of a very peculiar kind, and which, while they seemed to be a form of writing, were totally unintelligible to the most learned Englishmen in Dunedin and Auckland. It occurred to the Governor, however, that it might be possible the New Zealanders had formerly possessed a written language, all traces of which had hitherto escaped discovery. He therefore summoned the oldest and gravest of the native arikis of Maui, and demanded whether he could give any account of the document, or the characters in which it was written. The old man at first seemed desirous to deny all knowledge of either; but after urging, and the stimulus of some British threats, he consented to make a revelation of what had for many years been his nation's great secret. The Maories, he said, had formerly employed a written language. They were an educated people, and had numerous libraries; but when the British took possession of their islands, having heard that they were devourers of books, their great ariki made a decree that all books and manuscripts should be totally destroyed, with the view of starving the British and driving them back to their own islands. The decree was faithfully executed, but this one document seems to have escaped destruction; and this old Maori reluctantly lent his aid in translating it into English.

It will be noticed that the ancient civilization of the Maories was exceedingly analogous to that of the modern United States — many of the facts stated presenting a most astonishing parallel. This circumstance gives new plausibility to Mr. A. H. Keane's recently propounded theory that the Polynesian race is really a modification of the Mediterranean.*

The British have a foreboding that the New Zealander will one day stand on the ruins of London Bridge and moralize over the magnitude of the civilization gone to decay; but here the visitor from London Bridge may well contemplate with astonishment these traces of a vanished Maori civilization, which only by a mere chance has escaped from absolute oblivion.

The governor of New Zealand having sent me the translated document, I have the honor of being the first to bring it to the attention of the world. It possesses great archæological and ethnological interest. It reads as follows:

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*On this, see *Journal of the Anthropological Institute*, London, February 1880, *Nature* xxiii, 199-203 *et seq.*

THE KEWAHWENAW METHOD.

BY AN OPPONENT OF THEM LITTI RAREFEL HERZ.

Of all intellectual advances made in recent times, none surpasses in importance the introduction of the Kewahwenaw method; none promises more for the well being of properly regulated science, education in the three arz, and free (and easy) institutions. The whole range of recent history scarcely furnishes a parallel now standing in full tide of beneficent success, unless it be the manufacture of ensilage, or Per-redavy spanekil-her. True we have had high expectations concerning other modern ideas, which have been doomed to disappointment. I need only mention Stefensbat Terry and the Winanseeg arsteemer, to call to mind national calamities. The world was not prepared for advances so great. Madam Hau's Bah-stun bank promised a great deal,—more, indeed, than any other financial enterprise which has been set afloat; but it could not contend against the envy and malignity of those who had ideas of their own to promote. Madam Hau's gift-enterprise was crushed out in the most enlightened pah of Maui; and Madam Hau herself has been followed by the most relentless legal persecution. This, however, only shows that the Kewahwenaw method has not yet thoroughly taken in all parts of our country.

Of other great fruits of modern civilization still in the shell, none promise more than the Kiele moat-her and the Deless Epse bridge connecting the islands of Te ika a Maui and Te wahi Punamu. It is to be hoped that the rapid extension of the Kewahwenaw method, which is more a great moral conception than an invention, will save the Kiele moat-her and the bridge from that neglect which an over-brainy public is apt to visit on new enterprises which do not prove successful.

I shall not attempt to define the Kewahwenaw method too suddenly. I shall first make some statements concerning its merits, and furnish some illustrations of its useful application. It might tend to raise expectation too high to say it is a scheme for superseding the extravagance, inconvenience and aristocratic tendencies of the antiquated idea of personal competency for any duty. While this is true, it is obvious the whole import of the truth has not yet been adequately apprehended, since it is plain to any person who observes closely that the crowds who press for places demanding responsibility and intelligence are not yet altogether of the least responsible and least intelligent class. Still, it is gratifying to perceive a constant improvement in this respect.

Let us take a particular field for illustration; I refer to field-geology. Years ago, when our country had been but recently settled, the idea sprang up that the public territory might be carefully examined for the discovery of valuable mineral gums. Nu-Jerk, happily, was one of the first provinces to act upon this suggestion; but Nu-Jerk, unhappily, was under the chieftainship of that distinguished old fogy, Wilyum Elmarsee, who thought he could do no better than to commission four so-called scientific gentlemen (for science was then held in high esteem) to enter upon an elaborate plan which would require a decade for its accomplishment. The province once committed to such extravagance, it had to be subjected to the humiliation of seeing successive chiefs lend themselves to its indefinite continuance. It is some satisfaction to know, however, that they were men of no more worth or distinction than Wilyum Aitchswird, Si Lusrite, Hammil Tun-Fish, Horay Shoseemer, and the like,— peace to their ashes. It is probable the people of Nu-Jerk have been oppressed with taxes to defray the expenses of this survey to an amount exceeding a fiftieth of a mill for every man, woman and child in the province since the survey was inaugurated. This may seem an incredibly onerous burden, but I am in possession of certified documents to bear me out in the statement.

By the Kewahwenaw method these things are done without inflicting the least financial burdens on the untaxed poor. In the province of Kewahwenaw little value is placed, save in a surreptitious way, on the circuitous and fanciful processes of science, so-called. A man with a forked stick is better than a geologist with a hammer and pocket lens. He is cheaper; his method is more direct; he walks immediately to the bed of gum or vein of oil and puts his finger on the spot, and that is the end of it — I mean the end of your anxiety. Your fortune is now made, and it costs but seventy-five cents. Such a man can walk over the province and point out all its locations, while the man with a hammer would be cracking out a few fossils. He has another advantage; he wears a respectable system of tattoo, while the man with a hammer may be dressed in a suit of plain black skin. He speaks the language of the people; he finds coal in "veins," and fixes everything in "ranges;" the man with a hammer talks about chlorastrolites and polyglottophyllums, and idles away weeks in his roundabout methods,— and all this time under pay!

It will interest posterity to learn what were some of his old methods, now happily superseded in Kewahwenaw.

The information ought to be put on record, as it is likely to become an unauthenticated tradition. Well, in the first place, the old gentleman of fuss and fossils used to entertain a number of superstitious beliefs concerning geological structure. He talked with frightful sonority and ostentation about "groups," and "systems," and "dips," and "strikes," and "unconformabilities," and "faults." He believed that the different minerals were most likely to be found in particular formations, and he set himself to work — so he said — to ascertain what were the formations underlying the province, and what was their order of superposition ; so he built the phrases. What do the people care about formations which lie a hundred or a thousand feet beneath their yam-patches ? What they want more to know is what part of their farm conceals a coal mine or a kauri-gum mine. What do they care for "superposition," as long as they can see for themselves that a fortune in oil is revealed by the film on the creek, or by the rank aroma which stimulates their pituitary membranes and their cupidity? But the old-fashioned man with a hammer in his hand and a note-book in his pocket must proceed to make out a catalogue of formations in due order of "superposition." This, he told us, was the central problem to be resolved. How did he go to work?

I will tell you. He pretended there was a necessity for knowing something about the relative elevation of different parts of the province. The underlying strata, he said, are not placed horizontally and in regular succession. They have been tilted up, so that the edge of a stratum seen at the surface at a given point runs along near the surface for a considerable distance, and this he called the "strike." But, from the outcropping edge the sheet of rock descends in a direction nearly at right angles to the strike, and disappears beneath the loose superficial materials and the other formations. It is of first importance, he pretended, to ascertain in what directions the rocks "dip" in different parts of the province; for if a formation dips, for instance, toward the west from Oamaru, then it passes under all points situated west of Oamaru, and does not underlie points to the east of Oamaru. This is something of no earthly utility, but I am making a record of superstitions, and will proceed. If the man with a hammer desired to know the direction of the dip of a formation, one would suppose the most economical way would be to go and look at it. But he was not content with a method so direct and so cheap. He pretended that the dip was often so gentle that it could not be detected by a single observation. He pretended that it varied considerably from point to point, so that the position of the formation at widely separated points must be ascertained in order to know the general direction and average amount of the dip. Well, suppose all this was necessary, why not go to the two widely separated points and see what difference of elevation they have? As might be expected, the man with a hammer had new objections to the direct and economical method. He pretended it to be necessary to hunt up all the old road and canal surveys of the province, and transcribe their records of elevations, arrange them in tables, and lay them down on a map of the province. This was a long labor,—the man with a hammer all the time under pay. So he obtained the altitudes of all the principal points in the province. Now he argued that if the same formation was at the surface at two points, Wainui and Porongahu, twenty miles apart, and one of these points, Wainui, was a hundred feet higher than the other, then the formation dipped one hundred feet in twenty miles, or five feet a mile in the direction from Wainui to Porongahu. If by any means he could ascertain that the formation occurred at some point near Wainui, but at an elevation fifteen feet higher or lower than Wainui, then the dip between the two points would be fifteen feet more or less than a hundred feet. So he undertook to ascertain what he called the "dip" of the underlying formations in all parts of the province. Having come to a knowledge of the dips, he was able, he said, to calculate what formations underlay each locality. For, supposing Pipi-riki and Peri-riki to be twenty miles apart, and Peri-riki to be seventy feet higher up the river than Pipi-riki; and supposing the dip from Peri-riki down the stream to be five feet per mile, then the formation on which Peri-riki stands must pass under Pipi-riki, because the dip is more rapid than the descent of the stream; but if the dip is but two feet per mile, then the formation on which Peri-riki stands thins out and disappears before reaching Pipi-riki, and there would be no propriety in sinking a shaft at Pipi-riki to strike the formation which at Peri-riki may bear a valuable bed of kauri-gum.* The extravagance and inutility of this mode of operation are so apparent that I shall make no effort to expose them.

But the man with a hammer had a still worse crotchet in his head, and one much more wasteful of the people's money. Sometimes, as he pretended, it was impossible to get the difference of level of two points, as, for instance, Ateamari and Opepe; and therefore it was impossible to determine the dip of the rocks. Or, if the difference of level was known, the rocks in the two places were different, and it was necessary to know which held the highest stratigraphical position. Suppose he found the Ateamari rock to hold a position known by observation in other places to be fifty feet above the position of the Opepe rock, while Ateamari and Opepe occupy the same topographical elevation. It would be inferred that Opepe is fifty feet lower, geologically, than Ateamari. That is, going from Ateamari to Opepe, strata lower and lower in the geological series come to the surface. This means that from Opepe to Ateamari the rocks dip toward Ateamari to the amount of fifty feet. So he reasoned, and so he wasted his time,—all the while spending the people's hard-earned money. But how to know that the Ateamari stratum was fifty feet higher than the Opepe stratum,—that was the frivolous problem which he set himself to work out by means of what he called "palæontology." He pretended that each formation contained certain so-called fossil remains which were peculiar to it, and as soon as he could identify any fossil remains in the Ateamari formation he would know what stratum it is; and having determined the identity of the Opepe stratum in a similar way, he was in possession of a knowledge of the interval between them. Posterity will think all this very occult and extremely far-fetched. What the man who owns a kumara plantation desires to know is the depth to which he must dig to get soap or oil; and all the money spent in collecting and identifying fossils is entirely wasted,—and this the dear people's money.

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* These explanations are said to have been graphically illustrated in the margin of the manuscript, but the Governor of New Zealand did not transmit copies of the illustrations with the translation.

I have not reached the end of this system of scientific spoliation. Under such pretexts the man with a hammer went all over the province with his hammer in one hand and a leather bag in the other. He strolled along the courses of the rivers and smaller streams, gazing at the blank rocks, making diagrams of the cliffs, describing the strata, collecting, assorting and labeling the fossils, so as to know afterward what locality and stratum had yielded each one. He loitered about all the stone-quarries, bothering the workmen with idle questions; he knocked stone walls to pieces; he sauntered across the fields; he boated along the shores of the lakes; he clambered over the cliffs of the mountains,—and everywhere, with hammer and bag, he gathered fossils and samples of the rocks. It was a vain and frivolous expenditure of the people's money. Any inanga-catcher could have told him where all the cliffs were along the river or lake shore; and could have told him there was not an ounce of coal or a pint of oil in the whole valley of the Waitangi; and any hapuku-spearer could have given similar information about the whole west coast of Otago.

What did he proceed to do with these collections? He took them home, and occupied himself through the winter in handling them over, placing them here and there, and then placing them back again, as a child forever rearranges its playthings. He sawed them into thin slices and examined them with microscopes; he turned them over and over, he studied every point, and made every imaginable comparison; he drew innumerable pictures, and wrote books full of descriptions, and had the audacity to present them to the provincial authorities for publication at the expense of the dear people. That was the old established method. In Nu-Jerk the authorities have published such books in sufficient quantity to build a causeway across the straits from Otea to Moe-Hao. But did the authorities of Kewahwenaw acquiesce in such extravagance? Never. They learned a precious lesson at Nu-Jerk's expense. The plethoric treasury-sucker had almost succeeded in attaching himself to the public coffer. All disinterested patriots were watching for the opportunity to raise the cry of economy in behalf of the hard-worked and untaxed but numerous and heavy-voting yeomanry. It was a crisis in the history of Kewahwenaw. All eyes were rolling wildly for the martyr who should spring into the breach and rescue the money-box. Now rose majestically and patriotically from his seat the great Rangatira* Sammiheel. He stood up bravely and boldly in his place, in the grand council of the province, and most virtuously exposed and denounced the impending outrage. "I have traveled," he said, "by wheelbarrow express all the way from the mountains of Kewahwenaw to shake my greenstone tommyhawk in the face of this imbecile and fraud, and drive him to the solitudes of Rakiura. We have no use for him in Te wahi Punamu. He wants us to print seven or eight costly volumes of detestable trash about all creation, and ornamented with pictures and charts. It would bankrupt the province. It would cost a cent for every ten persons in Kewahwenaw. All we want is a simple volume giving a catalogue of yam-patches, kiwi-roosts and gum-beds,—a cheap, practical manual, in which every tutua and ware can find his name in dictionary order. Away with this gigantic, pedantic, romantic and satanic dun-seadd." Now, Rangatira Sammiheel was a nobleman of purest blood. He had himself carried the forked witch-hazel stick. His patriotism was tried and proven; no selfish motive ever found place in his expansive vest, and the breath of suspicion had never reached him. To this day his reputation remains as spotless as the sky of Maui. His heroic effort on this occasion ripped open the dark cloud which hung over the council and over Kewahwenaw, and by the gleam of light which fell through the rent could be seen Rangatira Harrihowlt rising like Tangaroa from the sea. Rangatira Harrihowlt also took his reputation in his hands and swung it over the heads of his fellow councilmen. "The day has dawned," he exclaimed, "when this scientific humbuggery must be stamped into flindereens. I have looked over the documents submitted by this strolling and conceited pedant and find nothing useful to our people. Here are some hundreds of rolls on the topography of the province,— what has that to do with the development of our soap-mines?* It is all bosh. Here is an equal number of rolls on our paradisiacal climate, which amounts to an invitation to all the hordes of Tonga, Viti and Papua to sail in on us and hold the fort. We don't want an immigration. We have sent an agent to Hawaiki to keep immigrants away. We have had to kill off thousands already in Maui, faster than we could eat them. This matter is all bosh. There are other rolls of infertile and infelicitous flummagery among these documents which I have not had the patience to bore through. They possess no practical use for our people. There is nothing here which could stand alone if wrapped in typography and put on its feet. It is all bosh."

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*This was explained by the old Maori as the title of one of the inferior chiefs,—perhaps equivalent to "Sir" or "Supe."

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* The learned councilman evidently alluded to soapstone quarries, which have been utilized to a great extent in increasing our supplies of butter, sugar and flour.

These were brave and ringing words. Such words had never before been uttered in Kewahwenaw. Gratitude soon raised their author to the rank of ariki. This was the natal day of the Kewahwenaw method. Rangatira Sammiheel was its father and mother; Rangatira Harrihowlt was its nurse. As soon as the event was accomplished, Masters Hairybald and Witterbacks, who had been sitting in an adjoining apartment, opened the door sufficiently wide to protrude their heads, and with hands covering the exposed angles of their mouths, called in a loud whisper to Sammiheel, "Magnificently done, Rangatira Sammiheel!" Now the power and effectiveness of Rangatira Sammiheel's eloquence is manifest from the fact that Masters Hairybald and Witterbacks had always aided and encouraged the man with a hammer, and, before they discovered his trick, had been strongly committed to the methods which he had pursued; but when Rangatira Sammiheel blew his blast, and turned the tide, they perceived themselves likely to be swamped, and called out wildly in unison, "Lord Sammiheel, we want to get into your boat!"

But the prescriptive power of science was not yet completely destroyed in Maui. Two chapters of later history show that the scientific disease still lurks in the blood of our tutua. The man with a hammer retained an influence over the ariki* of Hauraki. He persuaded the ariki to furnish his fossils a home. The ariki built cases and cabinets for him, made of totara wood, and adorned with ti. The Haurakians at length were persuaded that the arrangement of his specimens symbolized something in the order of events in times long past. They imagined the history of the past became reproduced, and that they obtained glimpses of the order and method of the world. They took in the scientific fanaticism so deeply that they even claimed there was something cultural in the contemplation of a stack of old bones. Of old bones collected at the people's expense he had an attic full. We all know how, when our ancestors first came to Maui from Hawaiki, the mountainous parts of our provinces were inhabited by gigantic birds, whose flesh served for subsistence during many generations. One of these species was of enormous magnitude, and when one tall man stood on the head of another, his eye was barely on a level with the moa's eye. The eggs of the bird were as large as the head of Rangatira Sammiheel. Unfortunately the big birds were hunted out of existence, and their bones now lie scattered from one end of Maui to the other. Well, the man with a hammer gathered forty tons of the bones of the moa, and got permission of the authorities of Hauraki to build a complete skeleton in the public place; and there it stood for six months—an old, black skeleton of a dead animal. This was more than our tutua could bear. The thing was frightful; it terrified the children and the women. It was aggravating; it recalled pictures of savory moa steaks, and excited appetites which the dry bones only mocked. Our prisoners of war did not suffice to glut the anthropophagous longings of our people. Lovers began to tell their sweethearts they felt as "if they could eat them up." The thing, too, was brown; its color was human. It was an insult as well as an aggravation and a terror. At length the keeper of the public place yielded to the dictates of his better sense and the clamor of the people, and had the thing whitewashed. But though the color was much improved, it was only a hateful, bloodless skeleton. It cost money even to keep it. So he finally knocked it to pieces and threw it on the rubbish heap outside of the palisades.

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* This is explained as meaning the higher class of chiefs.

Even in Kewahwenaw the influence of science still steadily exerts itself. There was another man with a hammer who came some time before from Hawaiki, the fatherland. Now the Maories always entertained a regard for the fatherland, which consisted of a mixture of reverence and affection. They considered everything from the fatherland superior to the productions of Maui; and especially was a scientific man from Tonga the object of flatteries and attentions. The Tongesan of whom I speak was a wise man. He never spoke of his plans. He seemed to be not only a fatherlander, but also one of the strictest of the Maories. He was tattooed Maori fashion; this pleased their fancy. He, too, began to go about with a hammer, and Master Witterbacks was mightily pleased with him. He opened a hole in the top of Master Witterback's head, and projected it full of science. He then closed the hole with a plug of puriri-wood. The stuff worked like vaccine matter; and Master Witterbacks began to pass himself for a man of science — head full of knowledge; heart large enough to undertake any duty the province might impose on him. Master Witterbacks kept his eye on the Tongesan. He told him where to go and what to do. The Tongesan was gentle as a Kiwi; but he was cunning as a Kou-kou. He had all the time a sly purpose which Master Witterbacks did not understand. He was getting up a picture-book — this pampered Tongesan plotter against our Maori institutions. And when the picture-book was ready he said to Master Witterbacks, "Master Witterbacks, now let us print this book, and never say a word to Rangatira Sammiheel about it." So the book was printed, and Master Witterbacks' name was set down in the book as high scientific engine-driver. And it was paid for out of the people's money; and the people never uttered a howl to this day, for they never knew anything about it; and Rangatira Sammiheel is in the mountains, and thinks science is killed as dead as a moa.

This is a true history of the origin of the Kewahwenaw method, and of its application to geological surveys in Kewahwenaw. But it is by no means local in its applications. Men with hammers have been among the rocks in other provinces. The application of the Kewahwenaw method to them varies with the circumstances, and with the disposition of the arikis, rangatiras, masters and councilmen in the different provinces. In the province of Makoketa they permitted a man with a hammer, who came from Nu-Jerk, to amuse himself a couple of years in collecting stones and getting up a picture-book; and the prototype of Sammiheel arose in council and told him to go home; they would not be nu-jerked; they would not pay the costs of his vagrant excursioning. So he went home howling, and howled for six years. Some time afterward another man with a hammer arose from among their own citizens. They told him they had use for him. They had a quantity of quarry stones to crack. They had a council-house to build, and would like to employ him in selecting and getting out the stone. They wanted him also to work in their gypsum quarries, and hunt up coal deposits. They would not publish any picture-books, but they would let him write letters to the newspapers; and thus he could ease his mind and relieve the editors, and all the expense of printing would be paid by the subscribers to the newspapers. As long as the people's burdens cannot be charged on the councilmen, in the political account, they are of no political value or importance. He was a good-natured man; but that was not the reason why he complied with their conditions. He actually hoped the Makoketans might, within a couple of years, be led to discern their own interest — their intellectual and educational interest — in having the history of past events in their province clearly portrayed to the intelligence of all. He hoped that he might be permitted at least to pursue a scientific method for determining the complete succession of their strata, and the economical products which they contain. But the Makoketans were too shrewd for him. They were ready for the economical products, but what did they want of "succession"? So the man with a hammer walked toward sunrise, and never stopped till he had gone as far as possible without leaving the shores of Maui.

The province of Mok-chehunk devised a much more ingenious and paying expedient. That province had long been infested with hammer-men, great and small. The people of the province had long been celebrated for their business sagacity. In the olden time they permitted a man with a big hammer to go about and explore the situation of their gum-beds. They induced him to communicate the "practical" results of his observations, flattering him with the promise to print a handsome picture-book for him, in which he could attempt to explain by what circuitous and wonderful processes he had attained those results, and how he had overturned the mountain range of Te wahi Punamu. But when his book was ready they justly refused to touch it. They banished him to a small island in the North Atlantic, where the villagers, who were all a body of refugees, took pity on the impostor, and got out his book in such cheap style as they could afford. He lived many years among them, — a good riddance to Mok-che-hunk. But the Mok-chehunkites, on the later occasion of which I speak, surpassed themselves. They turned the opportunity to publish, to their own advantage, in another way. There are among them extensive sellers of paper-rags and waste paper. These parties induced the grand council to print the books of the hammer-men. But it was not their purpose to allow these books to get into the hands of the hammer-men of other provinces. They kept them all in Mok-chehunk. They divided them up among the councilmen, rangatiras and arikis themselves, and the councilmen, rangatiras and arikis transferred them to the old-rag-men, and the old-rag-men sold them, and thus turned an honest penny; and there was no pandering to the vanity and ambition of the hammer theorists; and the old-rag-men swore that the same councilmen, rangatiras and arikis should always rule over the province, and keep on publishing picture-books for the hammer-men, as long as the Waitangi should flow into the sea. So the Kewahwenaw method, varying its application with the circumstances, has spread through the remotest provinces of Maui.

I have given so full a description of the application of the Kewahwenaw method to the suppression of men with hammers, that it will be readily understood how great is its utility in extinguishing brainy pretenders in other fields of aspiration. There are always persons who think themselves qualified for positions of responsibility, but who are totally deficient in that tact, alertness, cunning, bluff and brass which are the true qualifications for getting into position. Brainy people, moreover, have the vanity to think their services more valuable than those of bullet-heads and plumbiputs. Their pay-day has arrived. We have banished them from many judicial positions, and put men in their places who are content without robbing the people with extravagant salaries. We have generally secured cheap ferule-men and women to train our youth in the curricula; and even the high trainers in the grand currus, who style themselves proffysawers, are given traveling-papers in Kewahwenaw whenever their aspirations rise above fair Kewahwenaw moderation. We are aiming to crush out the whole breed of so-styled "experts." In a country like Maui all men are truly equal; and the person who sets himself up as superior to his fellow-men in any respect is immediately taken down and packed away in a row with his fellow-citizens, or banished from the country. There is nothing more beautiful than a civil society in which all men possess exactly equal power and privileges, and are recognized as equally qualified for all duties, and all, consequently, receive the same compensation for services,—a community which is not preyed upon by an over-cerebrated aristocracy, and in which the ancient superstition of special competency for any duty is a by-word and a joke.

THE GENEALOGY OF SHIPS.

A FEW years ago, on the breaking up of a meeting of the *American Association for the Advancement of Science*, we found ourselves, by the courtesy of the *Chicago and Northwestern Railroad*,* in possession of free passes to Omaha. Such a send-off for a body of low-salaried scientists was truly a god-send; and all who were truly wise used their passes. I well remember the eagerness with which my friend, Professor O. C. Marsh, packed his traveling-bag for a trip to the Missouri river, and the urgency with which he pressed me to join the excursion. There was an ulterior purpose lurking beneath his drab-colored hat which did not animate the others of the small company, who were intending simply to ride to Omaha and back. Perhaps this was one of those critical junctures in human life where to choose "leads on to fortune," and to refuse leads,—well, nowhere in particular. The fact is, Professor Marsh chose to go, and the present writer refused to go. The results illuminate the aphorism.

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* The government of this road has habitually manifested a generous appreciation of the needs,—not to say the claims,—of scientific enterprise. On this occasion (1868) members of the Association had their choice of three extensive trips,—to Rock Island, to Omaha, and to Lake Superior. Natural History in all its branches must be prosecuted by *observation.* This requires, many times, extensive journeys on the part of the naturalist. There is a double reason why he should not be taxed to the serious extent of bearing all the expenses of such surveys. 1. He is not in pursuit of a selfish end; he makes no material gains; all the results go into possession of the world; he expends his own time and employs the results of years of preparation without the least material compensation. 2. He is generally a low-salaried man; our colleges and universities pay less than business-houses to a good book-keeper or head-clerk; he is engaged in no profitable business; he can take advantage of no speculations; all his energies are withdrawn from money-making; his country taxes him on the books he imports for the extension of his knowledge; his generally scant resources must fatally restrict the field of his observations, and cause the world to feel the consequent loss, unless the intelligent appreciation of railroad superintendents shall prompt them to grant traveling favors, which cost their roads comparatively little. Since I have mentioned one generous corporation. I ought to say that most of our roads have granted important reductions in fare to members attending scientific meetings; and, in many instances, extensive excursions have been freely offered, which have proved of incalculable benefit to the interests of science. Some of the most noteworthy excursions offered the *American Association* have been from the meetings at Chicago, Indianapolis, St. Louis and Nashville. The authorities would be gratified, I am sure, to know what immediate and what indirect results have proceeded from these opportunities.

Not long after this the *American Journal of Science** contained an announcement of the discovery, by Professor Marsh, of the remains of a diminutive extinct equine entirely new to science. Beyond Omaha, Professor Marsh had proceeded over the Union Pacific railroad as far as Antelope Station, where the *débris* thrown out of a well contained the relics of this remote predecessor of the "prancing steed." It was at Antelope Station, in Nebraska, four hundred and fifty-one miles west of Omaha, that his destiny was revealed to him. From this happy stroke of good luck he had the tact and sagacity and industry to win the undivided affections of the goddess so generally reputed "fickle"; and a few years later the metropolitan dailies were enriched with voluminous accounts of his extensive and important discoveries; and all the world had heard that the ancestral horse had arisen in America, and that an American scientist had traced the pedigree of Hambletonian back to *Orohippus* of the Rocky Mountains. Professor Huxley had before this interested himself sufficiently in horse-lore to fit together some fragments of equine genealogy, and make an exhibition of them before the Geological Society of London.* I believe that he and Albert Gaudry and Paul Gervais had nearly convinced the geological *savans* of Europe that their continent was the native land of the domestic horse, and the whole line of his ancestry was European through and through. But it is certain that Professor Marsh came now to be regarded as fully demonstrating that the rôle which the equine played in Europe was merely by-play, and that America was both his primitive home and the chief scene of the exploits of the whole line of equidæ. True it was that from time to time the existing representatives of the equine lineage had wandered off to the European extremity of the North Atlantic continent,† and left their bones to stimulate the inquiries of "Old World" geologists. True it was that the domestic horse had been known through Europe and Asia during nearly the whole stretch of human history, while he was wholly unknown in America at the epoch of Columbus. But it appeared also true that the real domestic horse had lived in America and become extinct here. And it was apparent that representatives of the horse family had dwelt here in times much more remote than the epoch of the oldest known horses of Europe, and that the family had been represented by a much greater diversity of specific forms. It looked, in fact, as if America had been the original home of the horse family, and the domestic species had disappeared before historic times, simply because it had already been so long a familiar and characteristic American form.

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* *Amer. Jour. Sci.*, II, xlvi, 374, Nov. 1868. The discovery announced was *Equus parvulus* from the "later Tertiary of Nebraska." This was afterward thought to be generically distinct from *Equus*, and was named *Protohippus parvulus* Mh. (*Amer. Jour. Sci.*, III, vii, 251, March 1874).

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*T. H. Huxley, *Critiques and Addresses*, 181–217. Anniversary Address, 1870.

†See chapters iii and iv, especially the latter.

This, I say, was the conviction which became widespread among palæontologists in consequence of the chain of discoveries announced by Professor Marsh, from which it appeared that at least seven generic modifications of the horse-type had lived successively upon our continent.*

The very fact of the reality of so gently graduated a succession was deemed by Professor Marsh adequate ground for assuming that all these horse-types belonged to one line of descent, with some lateral ramifications.† To me, while admitting the high probability that the genealogical relationship was a fact, it seemed that the simple circum-

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*These were: 1. *Orohippus*, of the Middle Eocene; size of fox, and with four toes before and three behind; 2. *Epihippus* (a later discovery, however), from the Later Eocene, resembling Orohippus generally, but differing in the teeth; 3. *Mesohippus*, from the Oldest Miocene; size of sheep, having three toes before and three behind, and with large "splint" bones before; 4. *Miohippus*, from the Late Miocene; size of sheep, with three toes and small splints before, and three unequal toes behind, the lateral being diminished; 5. *Protohippus*, from the Early Pliocene; size of ass, having the lateral toes in each foot reduced to dangling hooflets; 6. *Pliohippus*, of Middle Pliocene; size of small horse, and having single toes with large lateral splints; 7. *Equus*, the genus of the domestic horse, known in America (*Equus excelsus*, at least) as early as the Later Pliocene, and in Europe (*Equus fossilis*, probably not distinct from the domestic species) in the Cavern Epoch of the Quaternary. In *Equus* the functional toes are reduced to the middle digit on each foot, but the rudiments of the two contiguous ones still remain as "splints." At a later date (1876) Professor Marsh discovered a still older equine, *Eohippus*, from the Oldest Eocene; size of a fox, with four functional toes before and three behind, like *Orohippus*, but with rudiments of a fourth toe behind, and hence, it is inferred, the rudiments of a *fifth* toe in front. The hoofs were mere thick, broad and blunt claws. The *Anchippus* and European *Hipparion* (*Hippotherium* in America) were closely related to *Protohippus*, while *Merychippus* was probably identical. *Anchippus*, *Hipparion* and *Stylonus* constituted a collateral series diverging from the equine stem. *Anchitherium*, from the older Miocene, and the oldest equine known in Europe, is similar to our *Miohippus*, but a little less specialized. It, or its immediate predecessor, probably carried this type from America in early Miocene times, after equines had been flourishing in the "New" World for a whole geological period.

† The same weight was afterward given to this class of evidence in Marsh's address as Vice-President of the American Association, at the Nashville meeting, in 1877. It may also be here stated that Professor Huxley had similarly assumed that this single line of evidence closed the door to all future argument or dubitation. This was in his New York lectures, in 1876, of which I have something further to say in another chapter.

stances of graduation and consecutiveness were not complete proof of the proposition; and to illustrate the fallacy of that mode of reasoning I sent the following *jeu d'esprit* to the journal which had been enterprising enough to keep the popular reader posted in the progress of Professor Marsh's discoveries: —

The intelligent public is placed under great obligations to the *Tribune* for early and extended accounts of the progress of American science. I have been extremely interested in the bulletins of Professor Marsh's explorations in the far West. The *Tribune's* re-presentation (in the number for May 4) of the subject of extinct equine quadrupeds on the American continent is entertaining and instructive, and made intelligible by the reproduction of the striking cuts showing the progressive historical changes in the foot of the equine animal.[‡] These, and other similar facts, are often cited as evidence of the genealogical descent of the domestic horse. The writer of the article of May 4 seems to view them as evidences that may sustain Mr. Darwin's theory, as he suggests certain physical conditions which may have given few-toed horses an advantage over many-toed horses.

Now nobody can be insensible for a moment to the beautiful exemplification of fundamental plan which we discover in these forms; no one can deny that the series constitutes an evolution; but some may question whether *Orohippus*, *Miohippus*, *Hipparion* and *Equus* stand in genealogical relationship to each other. To clear up all doubt on this question, and establish Darwinism on a scientific basis,

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[*] An excellent set of illustrations may be consulted by the reader in the *Popular Science Monthly*, lv, 295, Jan. 1877. These have been reproduced in the third edition of Dana's *Manual of Geology*, plate x.

I desire to direct the attention of readers of the *Tribune* to another set of facts with which they are all familiar.

I suppose the first notion of a vehicle for transportation by water may have been suggested to primeval man by the discovery that a floating log would bear his weight. Astride of such a ship, our ancestors may have paddled from shore to shore of their inland waters. We find an atavistic recurrence, or perhaps persistence, of this mode of navigation among the modern Australians. The discovery could not have been long delayed, however, that the buoyancy of the log would not be diminished by scooping out its interior and giving it improved capacity for passengers and freight. So the "dug-out" came into existence,—a form of water-craft so well adapted to the "conditions of [naval] existence" among many tribes of our North American Indians, that it survives as the fittest form of naval architecture. From the dug-out to the seal-skin *kyak* or the bark canoe, is but a step, and this step is an advance which seems to grow out of surrounding conditions. The Eskimo has no logs, but many skins; and the Chippewayan has, from the birch, a bark (whence certain vessels are still called "barks") more serviceable than logs or skins. These modifications of the primitive craft are obviously determined by the conditions of existence. And so the skiff on the mill-pond comes into existence in correlation with the lumber pile on the bank; and the brave, stout life-boat is bred by the many buffetings of a stormy surf; just as the biremes and triremes of the ancients came from the long-continued strain of the smaller boats by excessive loading and frequent swampings. All these forms of rowing craft sustain, admissibly, homological relations to each other, and teleological relations to surrounding circumstances, and show a regular developmental series. That is admitted, but the point which I wish to enforce as so happily illustrating and demonstrating Darwinism is that they sustain, also, *a genetic relation to each other.* Obvious as this is, many good people seem to doubt it. I shall therefore extend the argument.

How came the simple sail-boat into existence? Evidently the wind made it. Had there been no wind, there would have been no sails; therefore the wind is the cause of sails. But the simple sail-boat or Mackinac boat,—this is an obvious modification of the skiff. Here is only a marked divergence,—an incorporation of a new idea in water-locomotion, generated by an external condition of a marked character. But the divergence once established is likely to continue toward perfection. The little sail-boat grows into a sloop, with increased bulk, speed, complexity, efficiency and accommodations. The one-masted sloop develops into the two-masted schooner, and this into the three-masted brig, with ever-increasing differentiations and complexities. The reader will at once perceive the analogy between these masts and the toes of horses. The domestic horse is a sloop; the Hipparion is a brig. It disproves nothing that in naval craft the numerical progress is the reverse of what we see in equine craft. This corresponds with the different conditions presented by land and water for locomotive purposes. On the land, decrease in the number of organs; on the water, increase in the number of organs, is the condition of greatest efficiency; and we see in both cases how beautifully the result is correlated to the condition. Now, from the floating log up to the three-masted brig, we notice a series of forms representative of a series of ideas, and these sustain an evolutionary relation to each other in each series. These forms have evidently been evolved generatively. How else should they be found consecutive? The ancestors of the horse are found in *Pliohippus*, *Mesohippus* and *Orohippus*, and it seems quite as clear that the saw-log is the great-great-great-grandfather of the brig. Thus the ship, which rolls like a log (hence its record is called a "log-book"), has inherited an ancestral trait, like the man with a sharp tip to his ear.

Now, if the reader has followed me to this point without being convinced, I desire him to follow me on another departure. Just as the Ascidian from which man is descended, presented, in the course of generations, divergences which became class-types,—viz., fishes, reptiles, birds and mammals,—so the ascidian ship, in the course of generations, has developed three classes of vessels, viz., rowing-vessels, wind-vessels, and steam-vessels. The rowing-vessels answer to the sluggish reptiles; the sailing-vessels are probably birds, and the steam-vessels are New Yorkers,—of whom the Chicagoan is clearly a more fully developed species. It is probable that the vessels answering to the class of fishes are those like "monitors," "steam-rams," or torpedo-boats, or, perhaps, like those Atlantic passenger steamers which go under water. But I leave the fish-ships out of the argument. Now, I have shown that the genera and species of the rowing-class sustain genetic relations to each other, and that those of the sailing-class sustain similar relationships to each other and to the rowing-class. A few words will show that this relationship runs through the steam-class, and thus the whole subkingdom of water-craft. Look at the steam-tug,—strong, indeed, like a rhinoceros, but holding a low position in its class,—a position little elevated above that of a sailing-craft, and, in fact, incorporating all the fundamental ideas of that craft, except that engine is substituted for sail. The ferry-steamer is an improvement, but as the tug responds to a peculiar demand, so does the improved steamer; and each is the product of circumstances. The tug is all muscle; the ferry-boat is broader-shouldered, for bearing its load instead of pulling it. The river steamer is the outcome of the fluviatile duties of the ferry-boat. It arose in the epoch before the ocean-steamer, and must, therefore, have been its progenitor; and the Great Eastern is the "Kentucky Giant" of the whole class. Only this and nothing more, but there have been divergences from the straight line of descent, as we get aberrant mammals like the ornithorhynchus, the armadillo and the sea-lion. The urgency of surrounding conditions has called into existence such collateral types as Stevens' battery and the steam dredge,—all showing, by their fundamental plan of structure, derivation from the ancestral puffer.

I think the idea must protrude visibly. It is not that these forms in naval anatomy exhibit an evolution of the *idea* of a water-vehicle. It is not that they all sustain relations of fundamental plan to each other. It is not that they all show adaptation to special ends, suggesting to the minds of the credulous the notions of design and designer. This is the focus of the logic: They have all descended from an ancestral saw-log, and this appearance of common plan is not a plan, but only a family resemblance necessitated by the laws of inheritance; this gradual improvement comes from the struggle for existence, where-by the skiff robbed the kyak or the dug-out of the means of subsistence, the schooner robbed the sloop, and the brig the schooner, and finally the capabilities of these various craft have been developed by the demands of the circumstances under which they existed,— the intervention of intelligence and purpose is not to be thought of. Just as the proboscis of the elephant comes from the necessity of reaching beyond the ability of his short neck, and the reduction of the toes of *Mesohippus* from the desiccation of an ancient marsh (and the imagination of a modern *one*), just so a continual breeze developed the first sail; a longing for more rapid transit begat engine and paddle-wheel; habitual butting resulted in a steam-ram, and much hitting hardened the ocean-steamer into a monitor.

I hope now the case is clear.*

It would seem that the irony of the foregoing sally was sufficiently patent to any but a Jurassic Swabian. Manifestly, the reality of the genealogical succession of equine types is not denied, but only the assumption that the simple fact of succession (in connection with graduation of structures) proves that it must have been a *genealogical* succession. Yet, of the half-dozen or more responses called forth, several indicate that their authors had "failed to see the point," however protrusive. One signed "Direct Creationist," and conceived in a similar ironical vein, pretended to deny the relation of parent and offspring altogether, because, as he suggested, such relation could not be admitted in the graduated series of aquatic vehicles.

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*I am sure that Professor Marsh must have appreciated the entire good nature with which this little satire was aimed at a weakness in the claims set up for the palæontological evidence of derivation of species. He knows full well that I have always been in accord with all the world in conceding him the highest honor for the ability of his researches.

This was a pungent and capital rejoinder (I am not writing ironically now,—an explanation intended for Bœotians), and at first view seems to expose a weakness in the reasoning of my article. Here, he says, in effect, are two parallel graduated series: 1. A structural gradation in aquatic vehicles; 2. A structural gradation in successive equine types. Now, the author of "The Genealogy of Ships,"—turning his irony into direct speech,—tells us that because there is no genealogical relation in the first series it may be there is none in the second series. "Direct Creationist," however, takes the other alternative, and maintains (ironically, with the first writer) that because there is no genetic relation either in the first series or the second, there is no such thing as genetic relation anywhere. Or, converting his irony to direct speech, it means that inasmuch as we are certain that genetic relations exist in the actual world, we must admit that in the horse series, where family resemblances exist similar to those in the actual world, they imply similarly some real genetic relation. This is the argument of the rejoinder reduced to its simplest terms. But now, this is the very same old pretense whose validity I had challenged. "Direct Creationist" had simply masked the old *non-sequitur* and presented us a view *à posteriori*. The family resemblance in the succession of water vehicles is fully as exact and real as in the equine succession; and therefore, so far as the fact of succession is concerned, proves just as conclusively a genetic relationship. So after the two writers had grappled and completely rolled over once, it appears that the author of the "Genealogy of Ships" must be recognized as the upper layer in the scrimmage.

But it might be suggested that each term in the equine series belonged to one of the kingdoms of organic nature, in which genetic relationships constitute an eminent characteristic; while the forms of naval structure are known to possess no such characteristic. This was the purport of the replies of "Pikestaff," "I. J. K.," and "G. K. G." But right here lay the gist of my irony. It was *because* we could conclude the same thing concerning inorganic structures as had been inferred concerning organic structures that that mode of reasoning became reduced *ad absurdum.* Not that the inference concerning the organic series was *impossible;* it was simply not what was claimed—demonstrated. Admitted, with the utmost alacrity, that the genetic relation is a possibility in one case, and an impossibility in the other; yet, even in the possible case, there is another explanation which is also possible, — I need not say equally probable, — and that is *the possibility of a series of independent origins.* This is so far from absurd that it was almost the unanimous opinion of mankind till within a few years. It was defended by Linnæus and Cuvier and Agassiz. The latter stood up in the midst of the storm of opposition, and almost on his dying day flung fact after fact and inference after inference in the faces of the confronting army of Darwinists. So far is another explanation possible, not to say plausible. It is perfectly easy to conceive that each new type may have been a separate origination. Even if this *were* the case, we should expect that each new origination would be based on a plan of structure having all its fundamentals in common with preceding types. For why does any organism have such structures as it has unless to be suited to the conditions in which it is placed? And if the conditions remain essentially unchanged, why should a new origination be expected to have a structural conformation fundamentally different from its predecessors? The structure must remain fundamentally similar, even if it be a new origination; and thus, as Agassiz used to argue, a relationship of thought would be seen to run through the whole series, binding it in a unity as real as if threaded on a genealogical line. If, then, a series of independent originations is something so possible, and so defensible, is it not plainly a *petitio principii* to assume that genetic relationship is the *only possible* explanation of the graduated successions revealed in the history of the equine type?

There was another ground of hesitation to accept genetic relation as the necessary explanation of equine succession. So far as conclusive evidence had gone, genetic relationship was one of approximate identity. Inheritance meant reproduction or continuance of the same specific type. True, indeed, that susceptibility of variation coexisted; but all observed variation among individuals of the same ancestry exhibited but narrow structural range, and seemed to tend to disappearance. But the range of structure from *Orohippus* to *Equus* was great. They were not only different species, but different genera. Who had ever known generation to wander so far away from a primitive pattern? There existed, in truth, a real *want* of analogy between the relationships in the terms of the equine series and those in the generations of an established lineage.

One point only was suggested by the respondents which tended positively to turn attention toward genetic descent as the true explanation of equine relationships. "M. B. B."

raised the question of the significance of "rudimental organs." Now, the rudiments of a "row-lock" upon a sail-rigged vessel would be entirely inexplicable; but the rudiments of eyes in the blind fish of the Mammoth Cave become explicable, because we know they might be the effete remnants of functional eyes in some remote progenitor. Rudimental organs, then, it must be admitted, add a separate probability to the theory that equine relationships are relationships of consanguinity. The horse-series itself offers in its "splint bones" and other structures admirable examples of rudimental organs.

In this connection, it only remains to direct the reader's attention to the fact that the original article not only does not deny the probability of a genealogical descent along the equine succession of past times, but it does not deny the efficiency of the Darwinian principle of "natural selection." It implies that this is not an adequate and all-sufficient principle. Nor does it imply, in offering a parallel between a series of structures resulting from human contrivance, and a series of structures appearing in the natural world, that therefore the true and only conception of "designs" in nature is typified by the limited, groping contrivances of man. This was charged in the reply signed by "Pikestaff." In fact, the point of my satire did not depend on any assumption concerning designs in nature. If, however, it were needed to offer a reply to the Pikestaffian objection, — for it possesses a generic character, — I should point simply to the line of thought set forth in the last article of this volume. The Pikestaffian objection has become quite threadbare. I think the owners would do well to throw it now upon the pile of old rags.

There are many apt illustrations of the invalidity of arguing a material continuity in a series of terms connected by morphological relationships. One of the respondents to the article on the "Genealogy of Ships," "S. H. M.," regarded it "a good case of atavism in jokes," since, many years before, some writer in one of the English reviews had contemplated the articles of furniture in his study, — chairs, tables, bureau, etc., — as only a series of modifications of the three-legged stool. Another respondent, — and this is Pikestaff, again, — recalled Professor Morse's humorous lecture before "Section Q," in which an old hat was made to undergo, crayonically, a transformation by successive differentiations into all the types of head-gear known to man or woman. This was funny, as much cachinnation testified; but suppose Professor Morse had begun with the foot of *Eohippus*, and manipulated it in a corresponding way, he would have shown that horses, as well as hats, might be separately originated.

In another place I have instanced the history of the evolution of "wheeled vehicles,"* and this, it appears, has been taken up also by Mr. E. B. Tylor.† A kindred example, quite admirable in its completeness, is furnished by the historical and ethnical development of the plow. This has lately been discussed by Mr. Tylor,‡ and the general purport of it, so far as this point is concerned, may be condensed into the following statement of successive stages in the evolution. These, while taxonomically successive, do not, it will be seen, present absolutely a chronological successiveness. These facts, therefore, offer exactly the same phenomena as are frequently met with in palæontological studies.

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* *The Doctrine of Evolution*, pp. 90-1. See, also, *Reconciliation of Science and Religion*, 172-3.

† E. B. Tylor, *Journal of the Anthropological Institute*, London, 1880. Mr. Tylor had previously mentioned other cases, such as the evolution of fire-arms, the cross-bow, fire-drill, metallic axes, etc. *Primitive Culture*, i, 13-14.

‡ Tylor, *Journal of the Anthropological Institute*, 1880. The article is reproduced in *Popular Science Monthly*, xviii, 448-53. See, also, Tylor's *Anthropology*.

STAGES IN THE DEVELOPMENT OF THE PLOW.

1. A *simple digging stick*, the *katta* of Australia. This primitive type, like the foraminiferal one in palæontology, still survives.
2. A *two-pointed stick.* Still used by the Bodo and Dhimal of northeastern India.
3. A *bent* (or angulated) *digging stick* or "hoe." The *tima* of the Maories. Also the *hacker* of Sweden, from ten centuries back to within a generation. A similar but more finished tool was used in ancient Etruria and in Syracuse.
4. *Bent piece of wood*, three fingers wide, *fixed to a handle.* American Indians in modern times. Something similar in early Rome.
5. *Shoulder-blade* of an elk or buffalo (or a shell) *affixed to a handle.* Modern American Indians. The American Mound Builders used a *stone blade affixed to a handle.**
6. Implement with *metal blade fixed to a handle.* The Kaffir axe.
7. *Furrow-crook* or *large hacker*, drawn by hand. Sweden, within ten centuries.
8. *Plow-crook*, or furrow-crook with *share and handles separate.* Sweden, within ten centuries. A similar implement, drawn by men, with rope attached, was used in ancient Egypt.

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* C. Rau, *Smithsonian Annual Report*, 1863, 379.

9. *Plow-crook*, with share *shod with a three-cornered bill.* Sweden, after the last.

10. *Plow-crook*, like the last, but *drawn by mares or cows.* Sweden, after the *ninth.* Similar implement drawn by men in ancient Egypt. Plow with metal share and bent pole shown in an early manuscript of Hesiod.

11. *Common plow* with share, mouldboard, beam and handle. Fifty years back.

12. *Modern plow with coulter.* Something very similar was used in the time of Pliny.

13. *Modern plow with coulter and wheel.* The same was used with two wheels in the time of Pliny.

14. *Self-acting plow.* Recent times.

15. *Steam plow.* Recent.

Similar fundamental relations without genetic connection are exemplified in series of chemical homologues, where from one end to the other the contiguous terms differ simply by an arithmetical common difference. Edward von Hartmann has directed his attention to the defect in Darwinian argumentation on which I am here animadverting.* In referring to "the ideal and the genealogical relationship of types," he says, "it would be altogether too hasty to argue in the case of palæontological data from a simple *post hoc* to a *propter hoc*" (p. 11). The relationship of types in the mineral kingdom, he says, is purely ideal, not genealogical. Even in a case where the transitions proceed by insensible degrees, we are not authorized to argue, for this reason, that the successive terms have a common origin; for otherwise "one might assert

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*Von Hartmann, *Wahrheit und Irrthum in Darwinisms. Eine Kritische Darstellung der organischen Entwickelungstheorie.* Berlin, 1875. See especially pages 11, 12, 13, 15.

that the hyperbola had descended from the parabola, and this from the ellipse, and this from the circle or even, by disappearance of the minor axis, from a straight line" (p. 13). So again, speaking of the works of human art, he says: "If, for instance, it be said that the Gothic cathedral was developed from the Romanic, and this from the basilica, and this again from some sort of Roman market-hall; and if, further, it be possible to point out an insensible gradation from one structure to another, no one would consider himself, for these reasons, authorized to conclude that any given structure in the Gothic style had been produced by an actual transformation of the circular arch into the pointed arch. True, there exists here a genetic outgrowth of one type out of another, but yet only in an ideal sense, not in the actual structure. That is, the genesis is a fact, not as something external, but as a psychological genesis of thought and artistic ideal, one *conception* becoming historically developed out of the other"(pp. 15–16).

The palæontological evidence as proof of the derivative origin of species has been publicly discussed by Professor Huxley, and I invite the reader's attention to an examination of his method, as presented in the following chapter.

HUXLEY AND EVOLUTION.

The Direct Evidences of Evolution: Three Lectures in New York, September 18, 20 and 22, 1876. I. The Untenable Hypotheses; II. Circumstantial Evidence of Evolution; III. The Demonstrative Evidence. *New York Tribune* Extra, No. 36.*

FOR the complete, authentic, and accessible form of the lectures cited above, we are indebted to a phase of newspaper enterprise which is purely and creditably American. It is a pleasure to make acknowledgment of the great service rendered to science and literature in America by the cultured editorship of the *New York Tribune*, which discovers so large resources of "news" in the events and utterances of the world of science and letters.

The lectures themselves were widely heralded; every movement of the distinguished foreigner was made a sensation, and the whole country had been lifted to the tip-toe of expectation. The theme announced was one which had already agitated every thinking circle of two continents. Professor Huxley had long been distinguished as a bold leader in the advocacy of a hypothesis which required a reinterpretation of some passages of scripture; and a vague expectation had been awakened that some sort of a skirmish between science and theology was impending.

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* The report of the *New York Tribune* was "carefully revised by Prof. Huxley," and republished in *The Popular Science Monthly*, lvi, 43–72, 207–25, 285–98, November and December 1876, and January 1877. The titles given in this edition are I. The Three Hypotheses of the History of Nature; II. The Negative and Favorable Evidence; III. The Demonstrative Evidence of Evolution. Much of the two following articles is reproduced substantially from the *Methodist Quarterly Review* for April 1871. They will be found, however, to contain very extensive changes and additions

It is fair to record the fact, however, that no conflict with the fundamental principles of religious faith was anticipated by any holding representative positions in science; nor were corresponding representatives of theological learning fearful, to the least extent, that any phase of science so sustained by evidence as to be generally accepted by the scientific, could contravene the accepted fundamentals of religious belief. The popular apprehensions existed, as they have always existed, in the minds of one class who have no adequate knowledge of the nature and force of scientific evidence, and of another class who rather enjoy the spectacle when theology gets a pelting, even if with mere "tufts of grass." Undoubtedly it is the depraved heart which prompts to a large share of the satisfaction felt in such a case; but there seems to be also a semi-humorous element in our nature which enjoys, as a mild sensation, any discomposure manifested by theology at being even unjustly accused of jealousy toward science.

It is fair, also, to record the fact that the three lectures of Professor Huxley do not contain a single expression avowing or intimating an atheistic belief; and all assertions to the effect that "he more than suggested that his aim was atheistic" have no other foundation than the opinion of their authors that the doctrine of evolution means atheism. On the contrary, Professor Huxley has expressed himself in such terms as to clearly indicate that he reserves a place for original creative agency. He says:

"Though we are quite clear about the constancy of nature at the present time, and in the present order of things, it by no means follows necessarily that we are justified in expanding this generalization into the past, and in denying absolutely that there may have been a time when *Nature* [evidence] did not follow a *fixed* [first] order, when the relations of cause and effect were not [fixed and] definite, and when external agencies did not intervene in the general course of nature."*

And again:

"My present business is not with the question as to how nature has originated,—as to the causes which have led to her origination, but as to the manner and order of *the appearance of natural objects* [her origination]. * * This is *a* strictly [an] historical question. * * But the other question about creation is a philosophical question, and one which cannot be solved or *even* approached [or touched] by the historical method."

The first of the above quotations is not wholly unambiguous. It seems that the lecturer must employ the term "cause" in a physical rather than a metaphysical sense. He directs our attention to a time when the present order of nature had not begun to exist, and the orders of sequence of physical effects had not been ordained. He must have contemplated an adequate efficiency for the inauguration of the present order. In admitting the conception and possibility of a different order he at least implies the conception of a power superior to the present order adequate to begin, and therefore to end, its existence. The second quotation means clearly that the evolution hypothesis may be established, and yet leave every person free to satisfy himself in reference to both the efficient and the final cause of evolution. It means that the theist may posit a Creator at the beginning, and the scientist has no evidence to array against the position. This is clearly indicated by the nature of the change in phraseology introduced by the author in the revised edition. This quotation interpreted in its implications means, we think, even more. If natural history cannot reveal the nature of causal efficiency at the beginning of the series, it can no more reveal the nature of the efficiency which manifests itself at every term of the series; that is, the hypothesis of evolution authorizes the believer in immanent divine power to posit such a power in every term of the evolution. If the lecturer recognized such legitimate inferences from his language, it is greatly to be regretted that he was not more explicit. It would, indeed, have been a departure from strictly scientific method (in distinction from philosophical), but it would have been a courtesy appreciated, if not deserved, by the religious public. If, however, a scientist chooses to disguise his opinions on a theological question, or to refrain from forming any, it is probably his right to do so. There may be, nevertheless, a degree of reserve amounting to an affectation. The "science" of comparative religion teaches us that religious beliefs are part of the mental furniture, even of savages; and the inference from this is, that when a scientist studiously conceals his religious beliefs he is suppressing a part of his nature to copy a fashion, or to gratify a fancy for making an exhibition of an unsymmetrical mentality, as Chinese women pride themselves in half-suppressed feet, and our own women used to fancy a half-developed waist. It is not, of course, necessary for a scientist to make a parade of his religious beliefs; it sometimes becomes an unpleasant spectacle; but when he has never once made an unreserved avowal of such belief; when he has been extensively misconstrued, and half the world is on tip-toe of curiosity to learn his real opinions, persistent concealment looks so much like a desire to pique curiosity, or defy misconstruction, or court public mention, that indeed, public impatience must be excused. But it is to be hoped, in any event, that American dissentients from Professor Huxley's scientific or theological or non-committal positions will afford him no ground to complain of contemptuous criticism and misquotation.*

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* The words in brackets are contained only in the *Tribune* report; the words in italics are contained only in the revision as it appeared in the *Popular Science Monthly*. It would seem that the word "not" in the last clause is inadvertently employed, since it makes the idea incongruous with the one immediately preceding. The author apparently intended to say that "we have no right to deny that there may have been a time when external agencies did intervene in the general course of nature," or "that we have no right to affirm that there never was a time when external agencies did not intervene. '

Before proceeding to the consideration of the "Direct Evidences of Evolution," as presented by Professor Huxley, we desire to enter our dissent from some of his preliminary positions.

1. *The Miltonic conception of the creation is not entirely the biblical one.* Professor Huxley, in his first lecture, has presented us two "hypotheses" concerning the origin of the existing order of nature, which he pronounces

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*Those who feel curious to know more of Professor Huxley's theology may discover some faint light in a perusal of the article entitled "School Boards," in *Critiques and Addresses*. It will be noticed by the readers of Huxley's writings that he employs the word "theology" to signify a body of ecclesiastical principles and practices, and not the science of God.

"untenable." The first is the theory held by many of the Greek philosophers, though not by the greatest of them, — Socrates, Plato and Aristotle, nor by the Stoics and Eleatics, nor indeed by Xeniades, Democritus and Epicurus, — that the order of the world is eternal. The lecturer showed, as has been done time and again by others, that the succession of events in the past history of the world, as revealed by geological science, is such as *necessarily implies a commencement*, — a beginning of its organic history, and a beginning of its cosmical history. The second "untenable hypothesis" is that of "creation." For the purpose of making known his conception of the "creation hypothesis" he assumes that which is set forth in the epic of John Milton; and, after presenting Milton's graphic though grotesque picture of the origin of animal forms, proceeds to show that it is not scientifically exact. This was no difficult undertaking, since there was probably not an intelligent person in his audience, or in the city of New York, who would maintain that Milton's picture is a representation scientifically exact. It is doubtful if the poet himself regarded it as a literal history of events in detail. Milton employed a warm and productive imagination, and it might be affirmed in advance that the poet's pen would produce a picture whose exuberance of metaphor would prove eminently distasteful to cold and rigorous science.

Now, we cannot refrain from expressing wonder that a scientific gentleman, entering upon a scientific examination of theories of the origin of things, should pass by every scientific or philosophic exposition of the "creation theory," and go complacently to the glowing picture of a poetic imagination for the most rationally stated form of that theory; and that, too, a picture painted more than two centuries previously, when biological and geological science were scarcely in embryo. By the side of that picture, however, he placed the latest aspect of the evolution theory. The disingenuousness of such a comparison is grotesque. It is not asserted that Professor Huxley felt the comparison to be disingenuous. It must be assumed that he intended to be fair and just. We will admit, then, that he did not know the Miltonic picture to be a mere burlesque of the science of those holding the "creation theory." We will admit, in other words, that he had not informed himself concerning the theory which he publicly proposed to overthrow, but succeeded only in ridiculing.

But the lecturer attempted also to show that the Miltonic *order* of creation is not sustained by palæontology. Well, if the language of Milton means and implies what the lecturer claimed, we must admit that the scientific record diverges. But what was the necessity of setting up blind old John Milton and knocking him down again amid the jeers of such an audience? It would have been an equal feat to indict and convict old Thomas Burnet for the showing of his "Sacred Theory of the Earth." We can discover no explanation of this exploit, save the lecturer's belief that the Miltonic conception of creation "is that which has been instilled into every one of us in our childhood" [and that it is generally accepted as the most consistent form of the creation theory].* He does not pretend that in extinguishing the Miltonic

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* The words in brackets were omitted from the "carefully revised" edition. From this it might be inferred that the lecturer was aware that the Miltonic theory is *not* generally accepted as scientifically authentic.

[illegible] many of [illegible] greatest of [illegible] and [illegible] again by [illegible] the past history [illegible] a beginning of [illegible] his conception [illegible] that which is [illegible] and, after presenting [illegible] of the origin [illegible] it is not scienti- [illegible] undertaking, since [illegible] person in his indi- [illegible] who would maintain [illegible] exact. [illegible] as a literal [illegible] employed a warm [illegible] and it might be affirmed in [illegible] a picture whose [illegible] distasteful [illegible]

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[illegible]

good against the "creation theory" which he combats, it is the very foundation of another creation theory more in accord with the Sacred Scriptures. This parallelism of Genesis with science is a fact, whatever may be held respecting the supernatural origin of the record.

But now I cannot resist the temptation to return to Professor Huxley's starting point and attempt to ascertain what he proposed and what he accomplished. He set out with a promise to present certain "untenable" theories, and to argue them down. One of these is what he styled the "creation theory." Now creation refers to primordial origins. That which appears as a term in a series of physical causation may be said, in the language of science, to be "caused," but it cannot be said to be created. If evolution, as Professor Huxley maintains, is a self-operating process (however begun), then any new organism springing into being is not "created"; it is produced by evolution. In this view of evolution nothing in the course of natural events can be called created; and the lecturer argued logically from his assumptions. But then, if nothing in the course of natural events is created, it is quite clear that creation refers to something not in the course of natural events. That there must have been causal activity not in the course of natural events is obvious from the lecturer's argument that the course of events must be finite and not eternal. It therefore had a beginning, and some adequate power caused that beginning. The exertion of the power requisite to *install* a course of natural events was not an event in the course of natural events. It was an event incalculably greater than any natural event. It was a *primordial* origination not depending on any antecedent term, or uniform succession, or secondary or evolutionary cause. It was "creation." Why could not Professor Huxley assume that the defenders of the "creation theory" were logical enough to seek creation in an act which *is* creation, and not in something which one holding his view of evolution could not rationally denominate creation? And then, getting his eye once on that which can be recognized as creation, why did he not proceed to show that no such creation ever took place?

Happily the lecturer has himself supplied the answer to this question. He recognizes the certainty that the present course of events had a beginning; and he admits that we have no authority to deny that there was "a time when Nature did not follow a fixed order," and (if we understand him) "when external agencies *did* intervene in the general course of nature." Well, we believe this position to be sound; we also hold that an "external agency" acted before the "general course of nature was established"; and it must be this "external agency" which stands as the alternative of an eternal series in the explanation of the existence of the "course of nature." This relation of things brings to view a *real* creation. This is a creation which Professor Huxley suggests first by implication and then by declaration. Now why, I ask again, having brought the conception of a true creation clearly into view, did he not proceed to "demonstrate" that belief in such creation is an "untenable hypothesis"? Why did he turn from that which he had shown to be a fact, answering the requirements of creation, to something which, on his own assumptions, could not be viewed as creation? Did the sight of the enemy against whom he had registered an oath drive his courage away?

Let the lecturer stand up and testify again. "My present business is not with the question as to how nature has originated! The question * * * about creation is a philosophical question, and one which cannot be solved or even approached by the historical method!" Well, we can hardly find terms in which to characterize this procedure. The lecturer is promising to demonstrate that the "creation theory" is "untenable," and then, first of all, coolly tells us his present business is *not* with creation, since this is a philosophical question, and cannot be even approached by his methods. He then directs his artillery against something which he knows and admits is *not* creation, and at the end turns to us and says: "I told you I should demolish the 'creation theory,' and you see how handsomely I have done it!"

Now, I demand the reader's verdict that this proceeding has not accomplished what the distinguished lecturer claimed; that it is a proceeding little creditable to scientific discernment, and that Professor Huxley's whole treatment of the "creation theory" is perverted, disingenuous, illogical and farcical.

2. *The evidences adduced in support of the evolution hypothesis are not demonstrative, as claimed.* We think Professor Huxley has been carried away by enthusiasm in affirming evolution inductively "demonstrated," or in any way demonstrated. Still less is it demonstrated by a simple appeal to palæontological evidence. The final conclusion is even beyond the reach of inductive evidence; and if it were not, the inductive argument could never amount to a demonstration. The data of induction may justify the conclusion that gently graduated series of animals have succeeded each other in past time; but this is no proof

of a derivative relationship between them. The only possible inductive evidence of relationship would be a large number of examples of actual transition from species to species; but these, taking no account of merely inferential transitions, are facts of almost unparalleled infrequency, and at best are not of such observed frequency as to justify a generalization covering the whole field of life past and present.

GROUNDS AND CONSEQUENCES OF EVOLUTION.

IN spite of the objections presented in the last chapter to the breadth of Professor Huxley's claim, we are strongly persuaded that the doctrine of the derivative descent of animal and vegetal forms represents the truth. We discover no conflict between it and the "creation theory." We even maintain that a philosophic scrutiny of the doctrine will disclose the activity of creative power not alone in the region of "external agency," and inaugurative efficiency, but in every stage of that derivation which guides and employs biological forces with reference to preconceived results.

We have not been hasty to reach this conviction. We have pondered many a difficulty and raised many a query, but we have seen old difficulties vanishing and new proofs perpetually arising. We have learned more of the wonderful resources of the hypothesis in explaining the current and the exceptional phenomena of life and organization.*

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* Professor Huxley himself has undergone a similar change of opinion. In his address before the London Geological Society for 1862 he reviewed the palæontological evidences of progressive modification of types and concluded with the following inquiry and answer: "What, then, does an impartial survey of the positively ascertained truths of palæontology testify in relation to the common doctrines of progressive modification which suppose that modification to have taken place by a necessary progress from more to less embryonic forms, or from more to less generalized types, within the limits of the period represented by the fossiliferous rocks? It negatives those doctrines; for it either shows us no evidence of any such modification or demonstrates it to have been very slight: and, as to the nature of that modification, it yields no evidence whatsoever that the earlier members of any long-continued group were more generalized in structure

We now think it far safer to accept the hypothesis than to reject it. If it is safer for the scientist it is safer for religion. It is therefore time for the theologian to seek how to coördinate his essential faith with the impending finality of science.

It is not our purpose in this place to attempt any presentation of the facts which, in our judgment, as in that of the majority of scientific men, afford a strong balance of evidence in support of the doctrine of evolution through a material continuity. We may, however, indicate, in a synoptical way, the nature of the argument.

There is first, what may be called the *morphological evidence*, or evidence furnished by structural relationships and family resemblances among living animals and plants. Everyone understands what is meant by saying one person bears a family resemblance to another. It implies that there is a blood-connection between them. In some generation more or less remote their lineage converges, and the same parents stand as common ancestors to both persons. Precisely the same thing is involved in the statement that the dog, the wolf and the jackal have a family resemblance,—or the cat, the lynx, the ounce and the panther. The resemblances in these families are not so

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than the later ones."—*Lay Sermons and Addresses*, pp. 225, 226. In his address before the same society in 1870 he says: "When I come to the propositions touching progressive modification, it appears to me, with the help of the new light which has broken from various quarters, that there is much ground for softening the somewhat Brutus-like severity with which, in 1862, I dealt with a doctrine for the truth of which I should have been glad enough to find a good foundation. * * * When we turn to the higher vertebrata, the results of recent investigations, however we may sift and criticise them, seem to me to leave a clear balance in favor of the doctrine of the evolution of living forms, one from another." —*Critiques and Addresses*, pp. 186, 187. In 1876, after the presentation of the geological history of the horse-type to a New York audience, he concluded by saying: "That is what I mean, ladies and gentlemen, by demonstrative evidence of evolution."—*Popular Science Monthly*, lvii, 296.

close as in a human family; but they are of the same kind, and they impress themselves on us in the same way and with the same effect. We have not been accustomed to thinking of the members of the cat-family as having a common descent; but we universally recognize a close relation of structure, form, movements and instincts. Any one who should ask himself how resemblances of structure, form, movements and instincts arise, would at once perceive that they probably imply common ancestry. It is conceivable that separate species so characterized should have had separate origins; but our intelligence inclines to the other explanation. The reason of this is the fact that we are familiar with examples of more intimate family resemblance in cases of known consanguinity. The children of John Smith are quite certain to resemble their parents, and may reproduce predominantly traits of their grandparents or remoter progenitors. It is not needful to suggest similar illustrations throughout the animal and vegetable kingdoms. All our observation and knowledge, therefore, point to consanguinity as the cause of all family resemblances; and we have no knowledge of any other cause of them. There is no ground of hesitation to accept consanguinity as the true explanation, save our preëxisting assumption that all distinct specific forms are independent originations; and if we scrutinize this assumption, we perceive that it is held simply because it has been taught us in our childhood. That opinion has been thought demanded by our intuition and traditional belief concerning the relation of creator and the world; but when it is shown that the demands of this intuition and belief are better satisfied by the admission of a consanguineous relation among animals, it would seem that no ground whatever remains for the old assumption that each species is a separate creation. It is certainly safe, on the grounds of natural evidence, and, as I will attempt to show in the sequel, on the ground of religion, to admit that family resemblances among animals, as among mankind, imply community of descent.

This principle achieved, very much is found involved in it. Resemblances of the same nature as those called family resemblances exist between groups of animals and plants quite widely differentiated from each other. We do not say the mouse and the rhinoceros possess a family resemblance, but it is demonstrable that they do possess profound resemblances aggregating vastly more than all their differences. Their differences relate to size, covering, habits and other trivial circumstances; while their resemblances include skeletal frame-work, circulatory, digestive, respiratory and reproductive organization, as well as the general plan, arrangement, juxtaposition, connection and coaction of these systems, and all the minuter plan, substance, structure, development and action of bone, nerves, skin, fibres, membranes, etc. Finally, both have warm blood, respire air, and nourish their young with milk. How can we escape the conviction that these animals, also, owe their amazing similarity of constitution to their common descent from some remote ancestor?

But, if we compare the ox and the alligator, and free our minds from the customary impression made by their external contrasts, we shall find that almost the same identical catalogue of resemblances must be made out. The alligator is cold-blooded (comparatively), and does not nourish its young with milk. Its circulation is not completely double, though the rudiments of the same circulatory structures exist. If we extend the comparison to the fish, we have only to drop, in addition, the structure and function of aërial respiration, and all the rest presents a complete correspondence between the fish, alligator and ox. Thus, in short, the entire world of backboned animals is shown to be united by profound structural and functional relations.

If we stray from our starting point so far as to bring an insect or a worm into the comparison, we find still an immense preponderance of resemblances. All the invertebrates, like the vertebrates, possess the faculty of voluntary motion; they hunger and feed; they perceive; they have relations to each other and to the inanimate world; they breathe; they digest; they reproduce; they provide for, protect and defend their young; their whole system of physiological activity and coördinated structure is the same; they have mouth, œsophagus, stomach, intestine, liver; they digest by secretion of gastric juice, and imbibe the nutritive products of digestion; they appropriate the oxygen of the air, and aërate a fluid answering to blood; they have nerves which ramify to the various organs; they move by means of contractile muscular fibers; they rest from their labors at certain intervals, and sleep. Certainly, if a genetic relationship unites the different classes of vertebrates, it must also embrace the other animals which possess such a preponderance of resemblances with the vertebrates.

All classification is based on these resemblances. Classification, if true and correct, is therefore nothing more than the building of a genealogical tree.

There are numerous independent features of the morphological evidence. The heart of the warm-blooded vertebrate is divided by a septum into two ventricles. In the alligator the rudiment of a septum exists, as if either it were in a stage of development from the condition of the fish, or else of disappearance from the condition of the mammal or bird. The splint-bones of the horse's foot are, beyond all question, the rudiments of additional digits, — either digits in process of development, in the course of generations, or digits in process of disappearance. So the bird has a rudimentary thumb attached to the angle of its wing. Of the same nature is the stumpy caudal extremity of the bird's spinal column, the styloid prolongation of that of the frog, or even the os coccygis of the human subject. Here, as in many other instances, are structures which are rudimental, and perform no function, or only a greatly modified function, in the economy of the animal; while they are manifestly the same morphological elements or combinations as in other animals execute important and often essential functions. What do they mean? On the hypothesis of independent specific creations, it is necessary to suppose the Creator has introduced again and again certain parts which are functionally useless. On the principle that structures are adapted to ends, how are structures *without an end* to be brought under the rule of special creation? But now, if the theory of common genetic descent is admissible, all mystery vanishes. With progressive changes in the physical surroundings and necessities of the line of generations, some structures became more important, more exercised, and more developed, while others became less important, less exercised, and less developed; and some finally shrank to mere non-functional rudiments of their former selves.

Thus the world of contemporaneous existence affords ground for the inference that all existing animals are bound in a genetic system by the bonds of universal cousinship. It is of no import that we revolt at the thought. Perhaps the revulsion has no more rational foundation than taboo among savages. Perhaps the relationship, on reflection, will enhance to a sublime degree our comprehension of the system of organic life, and of the unity of all the world under the method of one intelligence. Perhaps it will appear that man's structure was not embraced in the scheme of derivative origins. Perhaps, if it was so embraced, he will be found to possess some distinct elements in his psychic nature which cannot be traced to lower existences. In any event, having felt the force of the evidence, it is manly to stand by it, and let the unity of truth determine the adjustment of the consequences.

We have, in the second place, what may be styled the *palæontological evidence.* The discovered records of extinct life upon the earth, it must be admitted, are extremely defective, and offer many instances which, in the present state of our knowledge, appear to conflict with the doctrine of descent, though there are no facts irreconcilable with it. That the record is incomplete, and must always remain incomplete, is obvious from a few considerations. The calcareous secretions of marine animals are the principal relics preserved. All animals without hard secretions have perished. The greater part of the hard secretions of animals has been destroyed by the action of sea-water and other agencies. Nothing of the terrestrial populations of the globe has been preserved except as chance transported them into bodies of water to be buried beneath their sediments. In the oldest rocks, moreover, metamorphic action has caused the disappearance of all species of fossils. Further, the fossiliferous rocks themselves have been but very partially explored. No region or locality has been exhausted, while the greater part of the earth remains totally uninvestigated. As a consequence of these imperfections in the data, it should be anticipated that the record would present many impassable gaps and apparent anomalies.

In spite of all this, palæontology has been able to establish the following principles:

1. There has been a *gradual improvement* in the structural rank of the leading types of animals as the history advanced from age to age.

2. The earlier condition of each animal type was a *comprehensive* one, in which certain characteristics of two or more later families or orders were united in one species.

3. The tendency of change has been toward the *resolution of comprehensive types*, so that the characteristics of each separate family or order should finally be embodied in separate species.

4. While this process of resolution of comprehensive types has been in progress, still further differentiations and specializations, both in the comprehensive and the resolved forms, have taken place.

5. The progress of discovery has gone so far that we have established not only a steady progression upward in the animal series at large, but also in several separate ramifications of the series.

6. Thus we trace tolerably continuous lines of succession. (*a*) From typical land saurians upward through Pterosaurs, *Archæopteryx* and *Hesperornis* to Carinate

Birds ; (*b*) From typical land saurians upward through *Iguanodon*, *Hadrosaurus*, *Compsognathus* and *Brontozoüm* to Struthious Birds ; though in both these series (only given in part) the types structurally consecutive are not always chronologically ranged in the same order; (*c*) The Camel series, ranging from *Poëbrotherium* through *Protolabis*, *Procamelus*, *Pliauchenia* and *Camelus* to *Auchenia*; (*d*) The Rhinoceros series, ranging from *Trilopus* through *Cœnopus Aphelops* and *Ceratorhinus* to *Rhinoceros*; (*e*) The Horse series, ranging from *Eohippus*, through *Orohippus*, *Epihippus*, *Mesohippus*, *Miohippus*, *Protohippus*, *Pliohippus* to *Equus*,— all these chronologically as well as systematically arranged. Also several other series quite fully made out, such as those leading to the Elephant, the Hog, the Deer and the Ox.

7. The tendency of fresh discovery is continually to fill up preëxisting gaps. Serial successions are being completed from year to year; connecting links are coming to light; terms once thought misplaced are found, through new discoveries, to be in proper successional order.

In this state of the facts it is perfectly legitimate to forecast results. Induction has established a law from which we may deduce anticipated results. We may reason then from what we expect to know, as well as from what we know.

We anticipate, accordingly, that in the course of time it will be shown that our earth has been the abode of complete successions of animal types, leading backward from each of our modern generic or family groups, by ever converging lines, toward ancestral centers; and from these centers, other lines pointing toward some common center in the remoter past. We expect to see the consecutive terms in these various series graduating structurally into each other, and every characteristic conformed and arranged *as if* there had been a gradual descent of all our modern mammals, along a set of diverging lines from some primitive, plantigrade, five-toed ancestor.

This is the generalization which the known facts and the known tenor of the facts authorize us to draw. But when we shall have become convinced of the existence of such a complete series of successional lines, we shall not yet have the demonstration of a genealogical connection between any two terms in any series. It will still be supposable, as stated in a previous article, that each term is a separate origination. We shall not yet have the demonstration that one specific or generic type has ever passed by modification, in the course of generations, into another specific or generic type. We shall have no demonstration that it is in the economy and plan of nature to permit specific transmutations. We may fairly argue that the facts accord with the theory of derivation, and are best explained by that theory, and lend it a high degree of probability; but we should feel our confidence materially strengthened if we could detect nature in the act of effecting a transition from species to species.

We have therefore, in the third place, the *variational evidence*. This consists of a body of facts tending to show that a species is not a primordial and permanent organic form, but only the existing phase presented by a line of progressive changes. Much light has been thrown upon this subject within a few years. Some cases of transmutation have been actually traced, and evidence has been gained that the gradational series connecting species of animals and plants, long regarded distinct, are in truth only transitional states of one of these species in its passage over to the other. More properly, intermediate states which have arisen simultaneously with the extreme states. In many cases the varied states seem to sustain relations to geographical position. Thus among plants, peculiarities of situation have given us varieties of the Juniper, Paper Birch, Chestnut Oak, Hackberry, Beach Plum, Black Thorn, June Berry, Wild Rose, etc. Among animals, extensive chorographical variations have been noted among Echinoderns, by L. Agassiz, A. Agassiz and E. Haeckel; among Molluscs, by Cooper, Barber, Weatherby, Lewis and others; among insects, by Packard, Edwards and Walsh; among fishes, by Jordan, Putnam and L. Agassiz; among birds, by Baird, Allen, Ridgeway and Coues; among mammals, by Baird, Allen, Coues and Yarrow. In other cases the variations seem to be due to marked changes in the physical environment of the animal. In a few cases it now appears that hybridity has resulted in the establishment of intermediate and otherwise variant forms.[*]

Among fossil Brachiopods the variations and connecting links are so numerous as to give rise to much perplexity and embarrassing synonymy. Mr. Meek described a common Cincinnati fossil as *Orthis biforata* with four varieties.* Professor Nicholson has taken our old *Chætetes lycoperdon*, a common coral of the Lower Silurian rocks, and enumerated no less than twenty-five distinct variations.† *Spirifera disjuncta* is a brachiopod abundant in Chautauqua county, New York, and neighboring regions, and of this Professor Hall has figured no less than eighteen varieties.‡ Of *Atrypa reticularis* he gives us, similarly, sixteen varieties.§ These technical names are edifying to the general reader only so far as they demonstrate that great variability has existed in the history of extinct forms, whether we attribute this to hybridity, geographical position or other causes, and furnish additions to the stock of evidence that it is the economy of nature to effect transmutations of species. The sum total of the variational evidence shows us that the derivative origin of types in palæontological history is a natural possibility. We are not in conflict with nature, therefore, in inferring that the terms of the palæontological series sustain a consanguineous relation.

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[*] For hybrids among trees consult Gray, *Man. Bot., N. U. S.;* A. de Candolle, *Treatise on Oaks;* Naudin, *Hybridity in the Vegetable Kingdom.* But compare Naudin. on the nature of heredity and variability in plants, in *Comptes Rendus*, Sept. 27 and Oct. 4, 1875, and A. Gray, in *Amer. Jour. Sci.*, III, xi, 153. On fertile hybrids of common and Chinese geese, see Youmans, in Quatrefages, *Nat. Hist. of Man*, 143; C. Darwin, *Nature*, xxi, 207, Jan. 1, 1880; *Kosmos*, April 1880, 77. On fertile hybrids of the mallard and muscovy ducks, see T. M. Brewer, *Proc. Boston Soc. Nat. Hist.*, Jan. 21, 1874. On fertile hybrids of hare and rabbit, see Gindre, *Bull. de la Soc. imp. Zoöl. d'Acclimation*, 1870, 659-67. On fertile hybrids of goat and steinbock, see Von Tschudi, *Thierleben der Alpenwelt*, 555; C. Vogt, *Köhlerglaube u Wissenschaft*, 66. On fertile hybrids of fox and dog, see Von Tschudi, *ib.* 413; C. Vogt, *ib.* 67. On fertile hybrids of wolf and dog, see C. Vogt *ib.* 60, *seq.*

But in the fourth place we have the *embryological evidence*. This seems to us to bring all the other evidence to a focus and complete the conviction that the derivative origin of species is a fact. It affords not only a picture of the succession of extinct forms, but it is a picture in which the successive terms are *known* to be

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* Meek, *Palæontology of Ohio*, pl. x. Compare Hall, *Palæontology of New York*, i, 133, pl. xxxii D.

† H. A. Nicholson, *Palæontology of Ohio*, ii.

‡ J. Hall, *Palæontology of New York*, iv, pl. xli, xliii.

§ J. Hall, *Palæontology of New York*, pl. li–liii. Compare Whitfield, *XIX Rep. N. Y. Regents*.

derivatively related to each other. Trace any higher vertebrate — man himself, if you will — from a primitive condition in the ovum. How marvelous, how awe-inspiring is the unfolding! We have first the yolk, with its "germinative vesicle" and "germinative dot." Then both undergo a succession of segmentations until there results a crowded mass of cells ("morula" or "mulberry" stage). Some of these dissolve, and the remainder arrange themselves as a hollow spheroid consisting of a single layer of cells ("planula" stage). The single layer becomes double, with an opening at one pole of the spheroid ("gastrula" stage); and now appears a thickening on one side, in the midst of which is disclosed the "primitive furrow," afterward to be inclosed and become the spinal marrow. An enlargement is seen at one extremity; this is the forming brain; and the various segments of the brain appear as gentle swellings. At the opposite extremity is a tail. Transverse marks in the middle of the neural furrow indicate the approaching vertebral structures; while certain segments along the place of the neck are seen to receive blood-vessels from the provisional heart, and to sustain completely all the structural relations of the branchial or gill arches in the type of fishes. Arms and legs bud out,— as yet without digits, or they may be viewed as unidigitate, like the limbs of *Lepidosiren.* Stumpy digits afterward appear, like those of the so-called *Cheirotherium* of Triassic times. The face goes by degrees through the conditions seen in low sharks, amphibians and higher vertebrates. Step by step the internal structures advance toward their destined forms, functions and positions. Thus, by a process of repeated differentiations, the complications and special adaptations of the higher vertebrate come into existence.

But what of all this? Very much indeed. This marvelous evolution which we see the higher vertebrate pass through is *absolutely identical* with the embryonic history of every other animal down to a certain point in its development. Every animal begins in the egg, and the eggs of all animals (we exclude shell and other accessories) are completely undistinguishable in structure. Every animal, except some of the very lowest, presents us, in its development, the morula stage. Every animal, with a few additional exceptions, passes also through the planula and the gastrula stages. Thus every vertebrated animal presents us the same primitive furrow, the same cerebral enlargements, the same segmentation, the same caudal continuation, the same vascular area, the same one-chambered heart, the same branchial arches and blood-vessels, the same progressive changes in the development of the brain, the same mode of formation of the enteric and abdominal cavities, the same beginnings of the formation of the face. This identity in embryonic histories may be unexpected; it may be amazing; it may be humiliating; but there is nothing better established in science.*

This is not all. There are living creatures which represent these successive stages of embryonic development. There are some so low that they never pass beyond the structure of the egg,—simple cells, often, like some eggs, capable of movement by means of prolongations of their substance. There are some which attain to the morula condition, and then are adult. Others pass to the planula stage, and still others to the gastrula. Certain worms (*Turbellaria*) represent a succeeding stage, as the Ascidians are believed to picture a still later one. Thus on, from the lancelet and the lampreys to the sharks, Amphibians, Monotremes, Marsupials, and Lemurs at the bottom of the four-handed animals, we discover living forms which stand forth in the museum of Nature as pictures of the embryonic stages of the highest vertebrate.

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* The reader will find the subject discussed in E. Haeckel's *Natürliche Schöpfungsgeschichte*, xi Vortrag, and *Anthropogenie*, xiii–xix Vorträge (translated and republished in New York as *Natural History of Creation* and *The Origin of Man*); A. Kölliker, *Entwickelungsgeschichte des Menschen u. der höheren Thiere*, 2d ed., Leipzig, 1876; F. M. Balfour, *A treatise on Comparative Embryology*, London, 1880. A general synopsis in A. S. Packard's *Life-histories of Animals, including Man*, New York, 1876; and a particular account of the history of the chick, in M. Foster and F. M. Balfour, *The Elements of Embryology*, Part I.

Finally, the embryonic series finds its parallel not only in the embryonic history of other animals, and in the adult forms of animals presented as we range up and down the scale of life, but the succession of extinct types, as far as we have read it, presents us with another parallel.

Now, while we *know* the stages of the embryonic series to stand derivatively related, it seems reasonable to infer that the corresponding forms in the realms of actual and extinct life are also derivatively related. It would appear, at first view, that the nature of the derivation must be fundamentally different in the two cases; but even this does not impair the meaning of the fact that, in both cases, we should have a *material continuity from form to form;* and this is all which evolution requires. On reflection, however, the mode of the continuity in the case of the embryo appears substantially identical with the assumed mode of continuity in the succession of geological types. Ordinary embryonic development proceeds through the multiplication and specialization of cells stimulated by the nutritive plasma in which they are bathed. Generative or genealogical development begins in the multiplication and specialization of a cell stimulated by contact with a cell specialized spermatically in the same individual or in an individual sexually different. Propagation, moreover, may be viewed as simply a mode of *perpetuating or renewing an individual* which is bisexual, either monœciously, as in lower animals and most plants, or diœciously, as in most animals and certain plants. The progress noted in the succession of extinct forms is assumed to have resulted from some influence exerted upon embryos in the progress of their development. The development accelerated or prolonged would end in an organism more advanced. This would be a new specific form appearing as a stage of embryonic history; and though many generations may have intervened while the embryo was arriving at this new specific type, we may view these generations as simply nature's expedient to continue the being in existence in spite of the wastes of physical life. So what seems at first a mere analogy resolves itself into a profound biological identity.

To sum up, we have, it appears, an identical order of succession of organic forms three times repeated. The first appears in the successive transformations of the individual being before it reaches maturity. This succession is *ontogenetic* and *rapid*. It is repeated for every individual which comes to maturity. The second succession is presented in the geological history of extinct life. It is not yet observed to be parallel in all details, but the progress of discovery tends continually to complete the parallel. This succession is *palæontological* and *slow*. The third succession is presented by the serial order of living animals according to rank. All the terms of the series are coexistent. This succession is *taxonomic* and *simultaneous.* The first succession represents the grand march of the animal kingdom as a whole; it is executed but once. The second succession is an epitome of this, continually rehearsed in the life march of individuals. The third succession is one without relation to time or place; it is ideal; it is a survival of traditions of the past, and condenses the evolutions of ages into one present and perpetual expression. PALÆONTOLOGICAL history exhibits a series in which the continued interpolation of newly discovered terms produces the suspicion of a perfectly graduated and genetic line. It suggests material continuity as a *possibility* and a *promise.* MORPHOLOGICAL relations present such continuity as something which, within the range of observation, is a *fact*, and beyond the range of observation is a *probability.* The phenomena of VARIABILITY reveal a disposition and an aptitude on the part of nature to fulfill the "promise," and make the "probability" completely a "fact." The data of EMBRYOLOGY *demonstrate* that the derivative relation of *such* terms as palæontology presents is an ever-repeated actuality. Now, with the work completed in the ontogenetic epitome, and with this proof of nature's *method*, and the variational proof of nature's *method* and *means*, it is little stretch of belief to grant that nature pursued the method of derivative originations during the whole period of palæontological history.

Now suppose it granted: (1) That geological history presents us universally, series of nicely graduated forms; (2) That these forms are all genetically related to each other, and that consequently all living forms are genetically connected. We have thus come to a knowledge of certain *facts.* We have only reached the determination of a certain order of succession, and a certain derivative relation. We have not yet discovered the *agencies* through which the derivation is effected, and the *conditions* under which those agencies are operative. Nor have we discovered the *efficiency* which operates the agencies, nor the mode of its activity, nor the reason why all these things are brought to pass as they are. In brief, after we have discovered *what* takes place, it remains to learn *through* what it takes place, and *by* what it takes place, and *for* what it takes place. These are the ulterior questions which were not touched by Professor Huxley in his lectures. He did not completely ignore them, but he waived them.*

Now, while the present occasion is not one for discussing these ulterior questions, it may be profitable to bring them into view for the purpose of enabling the reader to appreciate the vast breadth of the theme, and the separate subdivisions which must be clearly recognized in forming judgments about it.

I. What are the Physical and Physiological Conditions (mediate or scientific causes) of Variative Derivation?

It is in the domain covered by this question that the various theories of derivation have sprung up. At the outset a fundamental discrimination must be made. There are the organic activities appropriating material within reach, and building the organism according to a certain pattern; and there are the external conditions in the presence of which these activities are carried on. Whatever influence the environment may exert, it can obviously be no more than a *conditioning* influence, since whatever is done with the organic structure is done in the organism and through physiological processes and instrumentalities. Now, whatever may be the nature of the forces acting within, it is conceivable that they may be conditioned or determined in their activity by the quality and quantity of food, water, air, warmth and rest. These belong to the environment. Variations in the supply of these requisites depend on two classes of influences. These are the *natural* influences arising from daily, seasonal, periodical and secular changes in the supplies and from the movements and migrations of the animal. These variable factors have been taken into the account by the older transmutationists, Lamarck and St. Hilaire, and by the later Darwinists. Then there are the *artificial* influences (as we may style them) arising from the contests of individuals for the possession of the requisites of life. They might be styled the *volitional* conditions, in distinction from the *non-volitional* or cosmical conditions. These contests constitute the "struggle for existence," which is the peculiar feature of Darwinian derivative doctrine. The outcome of this struggle is always the "survival of the fittest," and a concomitant tendency of the specific type to improve. It is thus that the environment of cosmical or volitional concomitants may determine, promote or limit the organic activities of animals that have come into the world and entered upon the struggle for self-support. Undoubtedly the outcome of the Darwinian principle is of the nature claimed. We can only deny that it is a full and adequate explanation of all the facts.

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* He says: "The cause of that production of variations is a matter not at all properly understood at present. Whether it depends upon some intricate machinery — if I may use the phrase — of the animal form itself, or whether it arises through the influence of conditions upon that form is not certain, and the question may for the present be left open." *Pop. Sci. Monthly*, No. lvi, 210. "My present business is not with the question as to *how* nature has originated, — as to the causes which *have led* to her origination." — *Ib.* lv, 51. Our present inquiry is not *why* the objects which constitute nature came into existence, but when they came into existence, and in what order.— *Ib.* lv, 51.

But the most impressible period of life is the embryonic. To what an extent must requisite supplies during ovarian and uterine existence condition the physiological activities which are making the being what it is to be. It is certainly quite conceivable that favorable conditions should so accelerate embryonic development that higher results should be reached at full term, or that unfavorable conditions should so retard development that lower results should be reached. The influence of the struggle for existence upon the development of the embryo has not been entirely overlooked by Darwin, but *acceleration* or *retardation* as the consequence of a struggle maintained by the parent in the outer world is a conception which characterizes the derivative theories of Hyatt and Cope. It really seems to have struck upon a more fundamental and productive condition of derivative variation than the struggle for existence. The latter is a remoter condition, while the former exists close by the seat of operation of efficient cause. It accounts for regress as well as progress. It addresses itself to the tissue-making forces at the time when the foundations of the tissues are being laid and not when the organic structure has been already cast in its mould.

But now, independently of all external conditions, it is conceivable that the organism may be the subject of an inherent and unremitting nisus,— a tendency, in spite of obstacles, to accomplish certain results, and attain to fitter conditions. It is our own conviction that here lies the secret force which works out the multifarious phenomena of organic life. Such a nisus was appealed to by Lamarck; and Professor Huxley has more than once hinted the probability that it is a potent factor in vital phenomena. But it will be remarked that the admission of such a nisus is not a final explanation. An inherent nisus is causal, but not ultimately causal, unless we can attribute to it all the characteristics which manifestly belong to the efficiency which produces results in the organism.

When the question of *fact* has been answered; when the *conditions* under which the fact arises have been ascertained, and the physical or *physiological actions* in the organism which, under the conditions, work out the fact have also been determined, this is as far as natural science can go. The pure scientist may not care to extend his inquiries farther. But assuredly this is not the ultimate limit of rational inquiry. The human mind, in the complete scope of its symmetrical activity, discerns other questions and makes further demands. Let us glance at them.

II. What are the Efficient Causes of Variative Derivation of Species?

Plainly, it may become shown that the mode of activity of the organism, either conditioned or unconditioned by the environment, is the means through which the vital phenomena of the world are brought to pass, and we may still be ignorant of the efficient cause of that activity, or of the subject exerting the activity. Now, even though an indwelling and persistent nisus should appear to be the principal impulse to physiological activities, we have to seek after the source of the impulse. Does it originate in the tissue in which it acts? Is it a product of the tissue? These are the bottom questions, the solution of which possesses the highest interest for theology, and indeed for every seeker after fundamental truth. We do not propose here to enter into any argument; but for our part, it seems perfectly clear that the efficient cause of physiological changes, though active *in* the organism, is metaphysically objective to the organism in which they are revealed. Our conclusion is grounded, first, on our necessary conception of efficient cause; secondly, on the discernment reflected in the mode of activity of physiological causes. Efficient, — that is, primitive, original, *real*, — causation is the direction of adequate efficiency, through appropriate instrumentalities (if needed), toward a preconceived and desiderated result. If any supposed cause acts in any other way, then it is itself an effect, or an instrument, or a condition, and the real cause remains to be sought. If physiological force does not thus act, then, in tracing results to such force, we have not found their cause. Of such nature may be the "causes" with which science deals, but they are not rational causes. In this case we have to seek for the *volition* and *preconception* and *motive* back of physiological force. But if physiological force does thus act, then volition and preconception and motive are revealed in every vital change.

Thus we argue, even when force acts without adaptiveness. But vital forces act *with reference* to external conditions, and *with reference* to ideal concepts. Here is double proof, then, of intellectual discernments. Whatever results, therefore, are produced by the slow, perpetual activities of physiological forces, conditioned, to whatever extent, by the environment, are the results of an ever-present, discerning efficiency; and the more we see the organism moulded to the environment, the more clearly we see reflected the intellectual element of that efficiency. If the existing world is the genealogical result of primitive conditions, then the efficiency which the cycles of the past have witnessed in the transformation of successive terms has been enlightened by intelligence, directed by choice, and impelled by will. We cast our glances back over the awful chasm of cosmic æons, and contemplate it as the theater of the display of an infinity of miracles, revealed in an unbroken, sustained, adaptive and all-embracing system of evolution.

III. What is the Final Cause of Variative Derivation of Species?

We are properly reminded by the agnostic school that we must not presume to know fully the motives which actuate an infinite will. At the same time we feel fully persuaded that no intelligence acts without some motive — not even an infinite intelligence; for motive stands correlated to intelligence as such, and not the greatness of intelligence. We feel it, therefore, perfectly legitimate to inquire after the motives which have controlled divine activity in the ordering of the world. It is only the disclosure of motive which brings us into any relation of sympathy or mutual interest with another being. Absence of motive implies absence of feeling. The conception of activity without motive is the conception of a grim, heartless necessity. As to motive in the world, we shall not attempt to point out all which may be suggested. We are certain, in the first place, that the accomplishment of a result was a motive for the exertion of cosmic efficiency. And we are certain that coördinated parts of the cosmos have never assumed their places without the help of intelligent intention, no matter what human or higher uses the coördination may subserve. In the second place, the natural reason can never divest itself of the conviction that complicated and slowly maturing results which respond to the wants of sensitive beings were designed so to respond. Among the wants of intelligent beings are appropriate *stimuli* to mental activity, and appropriate rewards for mental effort. One of the highest and noblest stimuli to mental activity is the hope of attaining to the higher laws or modes of change and succession in the natural world, and thus approaching as close as possible into intelligent relation with the unseen and mysterious Power which sustains the world. The law of evolution discloses itself as the highest generalization of the phenomena of the cosmos. If we discover that this law involves not only an ideal, but a physical, continuity, we seem to have attained in cosmical dynamics to that unity which has been the aspiration of all science and all philosophy. This, then, is the highest possible disclosure of the Supreme Intelligence which nature can yield; and we shall expose ourselves to no just charge of credulity in thinking such a revelation of the Supreme Mind to be one of the final causes of the all-embracing scheme of evolution by continuity.

The world and its parts may be compared to a stately dwelling; and the scientist who investigates its constitution and the mode of its origin is like a visitor from some realm where houses are not built. This intelligent visitor studies inquiringly every accessible part. He catalogues the parts as the naturalist catalogues the members of the animal kingdom. He discovers a unity in the conception of the edifice, and says that its style is "gothic"; as the zoölogist says the style of a large portion of the animal kingdom is "vertebrate." But our stranger has never seen an edifice in process of construction, and he conjectures the method in accordance with which its features might have been originated and combined. Evidently, he says to himself, one method would be the full completion of each portion of the building before beginning another portion, as a mud-wasp builds its cell. At length, however, he discovers an edifice in process of erection; as the biologist studies the building up of an animal from the egg. An excavation is first made for the foundations; this is the "primitive furrow." The basement walls are raised around it; the sills and the floor-timbers are laid; these are the "protovertebræ." Next the side walls are raised and the roof is closed in. This is the median junction of the body walls in the embryo. Thus the most general features of the structure first appear. The places of partitions and stairways are indicated by rough timbers, and the plan of the house is outlined. As the work proceeds the rough timbers are covered with flooring and lath; then the walls receive coats of brown mortar, and, lastly, a white finish. Still remain the casings and mouldings, and paint and varnish. Now the house is complete, and our gratified stranger concludes that the stately edifice, the cathedral, the town hall, were all constructed according to a method of "evolution,"— the most fundamental parts first, the details successively filled in. He has discovered the method, the order of succession of the parts. Now he knows that all buildings are constructed according to a law of evolution; as the biologist has learned in reference to animals, and the cosmologist in reference to worlds. But our stranger could not for a moment imagine that the method or law of construction did the work of construction; nor can the biologist hold that the law of evolution accounts for the existence of the animal. The work in the edifice has been done by mechanics, with the use of tools and machinery. These are the physiological activities which build up the tissues and members of the animal. These mechanics act under the bidding of another will, and, in this relation, they are only a part of the mechanism which performs the work. Their hands are not the prime cause of the building,— they are not the real cause. The building would never exist if there were not a prime mover in the will of the proprietor. That will is the cause of the edifice; but this will has not ordained this structure without motive. Whatever the motive,— for residence, for display, for a monument, for some caprice, or for some motive undisclosed,— there has been a *why* for his determination.

Thus, in the contemplation of the universe, it is the part of science to catalogue phenomena and learn their mode and order of occurrence, and the physical agencies concerned in their production. But there are profounder inquiries propounded by reason, and deeper longings felt by the soul. After science has accomplished her last work in her especial domain, reason draws aside the veil which obstructs the vision of science, and discovers the Supreme Efficiency working in all things, and working out the welfare of sentient beings; and the soul arises and adores the God whose presence it before had felt, but now rationally cognizes.

THE METAPHYSICS OF SCIENCE.*

SCIENCE, taken in its modern and restricted sense, is a knowledge of phenomena and of their orders of succession.

Sensible phenomena are qualities or changes existing in relation to our faculty of external cognition. The relation is only that mode of existence, as to time, place or nature, which awakens in us a consciousness of power exerted upon us, and a reference of the impression to an external phenomenon as its concomitant. Qualities or changes which exist without such relation are not phenomena capable of constituting material of human science.

An order of succession or mode of sequence among phenomena may be cognized as invariable or variable.

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* The following discussion, reproduced by permission, with certain changes and additions, from the *North American Review* for January 1880, is intended as a protest against the assumptions made by a certain school of modern science. The pretense that any valid science can be constituted out of purely empirical material is a claim which exerts a predisposing influence upon those who feel averse to abstract thinking; and it has acquired a temporary popularity through connection with certain brilliant reputations. But the reader is requested to note the fact that the representatives of the school of scientific philosophy here criticised feel themselves irresistibly led, more and more as reflection is extended, into a recognition of those underlying principles of knowledge which, in their full application, vitiate the grounds of all purely empirical science. He is reminded also that those representatives of science, either in the present or the past, who have created the most substantial and enduring reputations are those who have united the philosophic spirit with the strictly scientific; while the utterances of those who deny or ignore the validity of all metempirical grounds of reasoning excite more the astonished admiration of the populace by loud and dogmatic affirmation than the respect and approbation of the thoughtful who make up the final verdicts on reputations.

When a certain mode of sequence is cognized as repeatedly and continuously occurring, we generalize by calling it fixed and invariable. The invariable order of succession of two or more phenomena is the *law* in accordance with which the occurrence of the sequents is regulated. The law being ascertained, we feel confident, whenever the antecedent is cognized, that one or more sequents will come into existence. We thus predict events on the strength of our confidence in the uniformity and irrepealability of the law induced. Whenever a mode of sequence is cognized which is not repeated, or is repeated only in such a manner that no regularity or uniformity is discovered, we record it, for the time, as a variable mode of sequence. We fail to induce the *law* under which the phenomena come into existence.

Yet we are psychically so constituted as to believe in the *uniformity of nature.* Even orders of succession which seem capricious or chaotic must imply some law under which they succeed, and in the eye of which they are invariable. In this intuitive faith we seek to discover the law.

The method of the search is the mental juxtaposition of two or more series of successions judged to be fundamentally cognate, and the selection of such terms in the juxtaposed series as exactly coincide with each other. These terms, thus observed to recur in fixed order, yield the law of their recurrence. The intercalated terms remain apparently adventitious, and must occur in accordance with one or more different laws which may remain undiscovered, or may be discovered, one by one, by means of the juxtaposition of a larger number of series, and the exercise of a broader mental power of holding phenomena before attention, and selecting the like and neglecting the unlike. This is well illustrated by the method of astronomy in selecting from an apparently chaotic mass of observations such as agree in time and position with a given set of observations, and thus afford ground for the elimination of the law of the motion of a newly investigated planet or comet; or the law of correlation between sun-spots on the one hand and auroral displays, magnetic disturbances or Indian famines on the other.

It is the work of science to extend as far as possible the knowledge of phenomena. It is its higher work to arrange phenomena into homogeneous groups,—that is, into series of successions in which the terms appear to possess some fixed relations of time, space or nature to each other. It is the highest work of science to *perfect* the classification of phenomena and induce the laws under which they occur.

The work of science has proceeded so far that innumerable phenomena, which were once regarded as isolated, are known to occupy fixed places in invariable sequences which come into existence under laws of nature.

Isolated phenomena,—that is, those not apprehended as sustaining relations of effect to antecedent phenomena,—were regarded in unscientific ages as occurring by chance, or through the momentary volition of beings possessing control of particular departments of nature, or of the whole of nature. A sentiment universal, and undoubtedly innate in humanity, prompts intelligence to recognize the existence of one or more superior beings, to whom the direct or indirect causation of phenomena may be ascribed, and toward whom a feeling of veneration may be directed. As fast as science has succeeded in relegating under law any of these supposed isolated phenomena, they have been viewed as accounted for and explained without recourse to the volition of superior beings. To such extent these beings have seemed to be retired from participation in the affairs of the world, and the religious feeling has been robbed of occasions for its exercise. Hence the progress of science has seemed to antagonize the religious sentiment. Science has, therefore, been denounced as atheistic, while, on the other hand, the religions of men have been despised as ignorant and superstitious.*

The immediate work of science, as just stated, consists of observation, comparison and induction. Obviously, a law reached by induction from facts is a principle from which other facts may be deduced; and this is one of the legitimate and characteristic processes of science. Science, in the full exercise of all its functions, is not, therefore, exclusively inductive.

Without observation, the material of science would not exist. There could be neither comparison, induction, nor deduction. Without comparison, no affiliated juxtapositions of phenomena would become known; and we should reach neither the laws which regulate them, nor an anticipation of other phenomena coördinated under the same laws. Without induction, the observation of phenomena would only create a mass of undigested material, like that which accumulated in the observatory of Tycho Brahe. Without deduction, the universe of phenomena would present the order and symmetry of a perfect machine, the products of whose activity we could know only as they were wrought out. Anticipation, — prediction, — and all the plans and operations based upon expectation, would have no place among human activities if science could not descend from principle to fact. All conceptions of phenomena that have not been objects of cognition must be based on deduction, proceeding from general principles established by induction from cognized phenomena. By such means science has affirmed the internal solidity of the earth, or predicted the eccentricity of her orbit at an epoch a million years in the future, or pictured her physical condition in a past removed from us by millions of years.

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* These thoughts are here only collateral, but the writer believes that they lie very near the true solution and peaceful determination of the "conflict between religion and science." He has elsewhere viewed these relations simply as a normal and not destructive interaction between the rational and the religious powers of man; and has offered an exposition which sets both religion and science in the character of forces exercising a natural, harmonious and beneficent interplay, like the mutual actions of the other polar forces in the universal dualism of the world. See *Reconciliation of Science and Religion*, 12mo, pp. 403, 1877, chapters I–III.

Such seem to be the scope and prerogatives of that department of science whose data are sensible phenomena. The term science, in its modern, popular acceptation, signifies the science of sensible phenomena. When the term is employed without qualification it is generally understood to signify *physical* science.

There are, however, other fields of phenomena — using the term in an extended but legitimate sense — cognizable through internal, instead of external, perception. The phenomena of the mind have an existence as certain, and orders of succession as fixed and cognizable, as the phenomena of the external world. The reality of mental phenomena is absolutely unquestionable. They are, in fact, the only data of demonstrable knowledge. Sensible phenomena are only names which we ascribe to assumed external manifestations *believed* to be coördinated with cognized internal phenomena. Hence the certainty of external phenomena is conditioned on the validity of this belief. External phenomena, therefore, cannot become so immediately, even if they are so certainly, the materials of valid knowledge, as those phenomena which arise in the mental field.

Among the phenomena of consciousness we have to make, therefore, the following discriminations: *First*, Mental states, or psychic modes, without regard to their sources, occasions or coördinations to any other facts than mental states; *Secondly*, Those among the mental states which we irresistibly refer to external phenomena as their correlates and causes. But there is also a *third* category of mental states, or inner perceptions, which we irresistibly refer to abstract and necessary truths.

The truths thus cognized as having a necessary, universal and eternal existence are truths concerning necessary being and necessary relations. Space and time are existences which must be held necessary in the same sense as other truths are necessary; and the relations of portions of them are relations of quantity, which are formulated in well-known axioms and theorems, embraced among the necessary truths which stand as correlates to the third class of mental states. Other truths are the inseparableness of quality and substance, attribute and being, effect and cause, order and intelligence, continuity of existence, universality of law, ultimate unity and ultimate primordiality of existence. Some of these principles have generally been omitted from enumerations of necessary truths; and the reader, if he think proper, can omit them here, as the main purpose is simply to adduce illustrations, and not to establish a catalogue.

Finally we discern a *fourth* class of mental states. These are the assumptions which we irresistibly make of an absolute causal relation between certain conscious states and realities external to consciousness. We find in existence an assumption that certain states are caused by sensible phenomena; and an assumption that other mental states are caused by the disclosure of certain abstract truths; and an assumption that these abstract truths have a necessary existence in the universe of which we are a part. We find here, also, the assumption of personal existence and personal identity. This fourth group of conscious states impresses a belief in the reality of sensible phenomena; in the reality of existence behind these phenomena; in the reality of supersensible existence underneath all psychic phenomena, and in the reality of truth apprehended as universal and necessary. These subtle, instantaneous and irresistible *assumptions* are the only bond of connection between us and any realm outside of our own minds. Invalidate them, and all which seems to exist, either in a world without or a world within, resolves itself into a phantasmagoria of forms without substance,—a succession of mental states which seems to have a cause and correlative, but has none; a succession which seems to be concatenated and orderly, but is absolutely chaotic and fortuitous; a succession of states which, after all, are not states, but only the alluring and deceptive images of states,—and not even images, for the seeming must be as fanciful and illusory as the seeming of substance. Deny the validity of the assumption of causal correlations between mental states and realities, and all knowledge is annulled. We float only in a glittering realm of empty forms,—we cannot say we float, but we seem to float,—we cannot say we seem to float, but we seem to seem to float. All predication is annihilated. We are conscious at first of existing in a world of realities; then we float in a realm of unsubstantial visions; then everything,—visions and realities alike,—sinks into absolute nihility. Such denial is the end of all philosophy and all science alike. What do we say? All science and all philosophy depend for their validity on the validity of our reference of certain mental states to causal correlates external to the mind.

That the reference is valid, no one can doubt in a practical manner. Denial, even of the speculative kind, is impossible. The utmost which speculative thinking has ever been able to do is to affirm the *possibility* that such reference is invalid. The history of philosophy has shown that the most eminent propounders of this possibility have found, in after life, satisfactory ground for holding that the reference is valid; and that, therefore, a realm of reality exists, and that it is such as reported in consciousness.

Every argument between two parties must proceed on the fundamental admission that those states of mind which have been here described as announcements of a correlation between other states and external realities are truthful announcements. If either deny this, he deprives himself of all ultimate ground for either affirmation or denial; and his attempt to reason is like the effort to move the world without the basis for a fulcrum.

After this *conspectus* of the situation, let us examine more attentively the foundations underneath the fabric of physical science.

The current conception of physical science presents it as a body of knowledge. It is commonly regarded as the most certain of all knowledge, and the safest foundation for belief, expectation and action. Men stand firm on the conclusions of science, however they falter on the isolated propositions which science subsumes. They formulate their creeds on the dicta of science, though they may profess to doubt or be ignorant in the presence of the naked principles which authenticate the dicta of science.

That science attains to valid knowledge cannot be rationally denied. Instead of denying, it is our purpose to demonstrate that it is valid; and that it is valid because certain underlying principles which science never mentions are the firm foundations on which it rests.

I. All science begins in the assumed existence of a real, thinking being. But what is the ground of the assumption of our personal existence and personal identity from moment to moment and from day to day? The conviction is grounded in our inmost consciousness; we are unable to resist it; but it is only a *belief* — a valid belief — the ultimate elemental utterance of mind, speaking with the authority of its very being. Nothing, of course, can validate its utterance; but, if we choose to admit a speculative doubt, we negative at once all possibility of science and all possibility of a scientific basis for anything.

All trustworthiness of memory rests in the presupposition, not only that the representative faculty is a true witness, but that we are the same being as yesterday. The scientist records his notes after hours, days or weeks have passed; and he builds most serious reasoning on the assumption that it was he who made the observations which he seems to reproduce. If he is mistaken in this,

his reasoning is illusory; but he builds, sometimes unmindful of the fact that his fabric rests upon a purely and deeply metaphysical subsumption.

II. Admitting the evidence of personal existence sufficient, other queries immediately arise which must be disposed of. Science we have defined as beginning objectively in a knowledge of phenomena. Now, how do we know that phenomena exist? or that they exist as they seem? or that any reality lies behind them? or that the reality is such as it seems to be? Plainly, all these things are assumed on the naked testimony of the mind. Consciousness reports phenomena, and we believe. Consciousness represents them thus and so, and we believe. And then we find disclosed in consciousness a confidence that all phenomena are grounded in real existence, and that such phenomena as these are grounded in a mode of existence sustaining an exact correlation to these particular phenomena. This confidence is only belief in the ultimate verdict of our being. *All science, to be substantial, must assume the validity of all these ultimate beliefs.* The most logical conclusions of science must necessarily imply that there are some propositions which do not admit of logical proof, but which must be received with absolute unreserve. These ultimate propositions are simply believed without reasoning; but our belief is so strong that we feel it to be knowledge. If it is not knowledge, the fabric of propositions which we build upon it is not knowledge. If it is knowledge, then the plain, simple, ultimate utterances of our minds are the indestructible molecules of all our systems of science; and the testimony of consciousness respecting the coördination between any of its states and external realities is a direct intuition of truth.

This conclusion cannot be avoided. The reality and genuineness of our knowledge of the phenomena assumed as the material of science is absolutely conditioned on the veracity of consciousness in certain of its testimony. Impugn this veracity in any respect, and the genuineness of the materials of science is correspondingly impaired. The more valiantly we affirm the indestructibility of scientific knowledge, the more explicitly we admit the unimpeachable veracity of the testimony of consciousness. If consciousness is not admitted as a veracious witness thus far, it is impossible to hold an argument with the reader. If consciousness is admitted veracious, so far as to validate the phenomena from which science proceeds, we may next inquire what are the further implications of scientific knowledge.

III. Supposing the facts of observation to stand in every respect unchallenged, some principles of relation must be tacitly assumed to serve as the ground and authentication of any classification. Whether we associate them with reference to time or place, concomitance or succession, quantity or quality, it is in every case a basis of resemblance. Without some kind of mutual resemblance, no homogeneity or community would be present to justify any general predication. But when we adopt any kind of resemblance as the basis of classification, we tacitly assume that likeness among phenomena proceeds from community or identity of *cause;* in other words, that "like effects proceed from like causes." This is a principle which must be validated by pure reason to acquire that character of certainty, universality and necessity which we assume it to possess in the use which we make of it. If it be thought a principle resting on a general induction from observation, then admitting (contrary to the fact) that the same absolute certainty could be reached, the very process of generalization assumes still the same principle, that homogeneity of phenomena implies similarity of cause. Hence, when we look to general induction for the validity of the principle that like results proceed from like causes, we find that the induction itself assumes beforehand the validity of the principle; and our effort is simply a case of reasoning in a circle. As general induction cannot, therefore, validate the principle which validates general induction, it follows that the principle is validated either by deduction or by the direct sanction of pure reason. But it is not a deductive conclusion, for the principle itself, possessing the highest degree of generality, is not the result of an analysis. We discover no account of the validation of the principle except in the sanction of the same rational authority as speaks to us in affirming a correlation between certain conscious states and external realities. Here, then, in the first step which science takes in formulating a general concept or scientific doctrine, it is absolutely necessary to rely on the universal validity of a principle which cannot be established by scientific processes, nor indeed by any formal logic whatever.

So, it may be added, the whole search after general laws, or the unification of human knowledge, is prompted and guaranteed by the intuitive conviction that *unity* exists among the diversified phenomena of nature. If no ulterior unity existed, or if reason were not furnished with the knowledge of its existence, the search for general laws and deeper causes would never be undertaken, or, if undertaken, would be fruitless.

It is extremely easy for the scientific investigator to overlook a metaphysical principle involved in the comparison and classification of concrete phenomena; but since the principle clearly reveals itself to critical attention, we must frankly acknowledge that the entire fabric of physical science rests upon a truth grounded in the realm of metaphysics; and that this is not for such reason a truth "merely speculative" in the reproachful sense, but a truth which is self-evident, and surer than any scientific conclusion. To a certain class of minds such a statement may not address itself with all the cogency of a concrete proposition, but it may impress the necessity of caution in vaunting scientific conclusion from sensible phenomena as the most certain kind of knowledge, and incomparably more substantial than the ethereal abstractions of metaphysics.

IV. When, in the progress of our scientific investigations, we reach the stage of inductive inference, the process of concluding from a part to the whole is based on an assumption of the uniformity of nature, which is only the concrete form of the principle that like results proceed from like causes. If unobserved phenomena belonging to the same group with those on which the inference is based are not ascribable to the same cause, or same kind of cause, we have no right to extend the inference from observed data to these. But the principle of the uniformity of causation is accepted as more valid than any inference which we may induce from any array of phenomena, however extended. The inference may express a bond of connection running through the phenomena observed, and no others; it is therefore not a causal bond. It may express a causal bond, but not the deepest and strongest bond. In any such case the inference is liable to fail in its application to new phenomena. The inference, therefore, can never be unreservedly accepted except when the facts sustain quantitative and therefore mathematical relations to each other. But however qualified the inference, the metaphysical principle on which it proceeds is never accepted with reserve. Uniformity of causation is felt to be absolute. The common process of inductive conclusion, which is the staple method of science in the evolution of doctrine, requires, consequently, an underlying metaphysical principle to give it any semblance of validity.

To avoid misconception it may be desirable to state that the phrase "uniformity of nature" as here employed, does not signify simply a continuous recurrence of identical cycles of phenomena, like those of a day, or the orbital revolution of a planet, since such uniformity is merely a generalization from observation, and must be conceived capable of interruption. When this uniformity, however, shall have been interrupted, it will be a result proceeding from a higher principle of uniformity, which requires that different effects under changed conditions shall proceed from the same causal activity.

So, it may be-added, the uncertainty which, in any case, or in all cases, hangs over a conclusion from inductive data, arises not from any possible distrust of the principle of uniformity of causation but from the possibility that our imperfect judgment has admitted into the comparison facts belonging to different categories of causation, and therefore connected only by superficial or casual instead of fundamental relationships. Here lurks the fallibility of inductive conclusions; and here arises the demand for profounder perceptions than finite minds possess.

V. Granting the highest attainable validity to the successive steps taken by science in attaining its ultimate generalizations, these are expressions of laws under which successions of phenomena come into existence. The order and method of the cosmos are so far revealed. Its phenomena become intelligible in their mutual relations. The flow of events is systematic, certain, predicable. Nothing happens capriciously, or with any regard to interjected emergencies. No variation in the established order of events can be expected under any supposable circumstances. This is the "reign of law." No ground exists for denying that this reign embraces all the events which make up the history of the irrational world. Nor can it be denied that all rational activities proceed according to some law; for otherwise there would be no evidence that they are rational. But the laws of rational activity inhere in rational spontaneity; those of physical events are imposed by external authority.

But the reign of law means nothing more than the universal prevalence of methodical successions of events. Law is the formula under which events are coördinated; but law does not produce events. A phenomenon is scientifically explained when we refer it to the law under which it takes place; but it is not exhaustively explained. For the purposes of science it is adequate to ascribe events to law, because law is the ultimate stadium of scientific ratiocination. It lies on the remotest frontier of scientific territory. Physical law is itself an abstraction, and constitutes the connecting link between the physical and the metaphysical. But when we say, in the language of science, that events "come by law," we must take care not to conclude that law is their cause. Law explains their order of succession, but does not explain how the law came into existence, nor how events are generated, nor how they are coördinated so methodically. Law is simply the rule of coördination; efficiency produces them and coördinates them.

Law viewed scientifically is merely a rule of succession; viewed philosophically it is an expression of power and intelligence,— a synthesis of force and mind. In the purview of science, law is the key to unlock the methods of nature,— a clew to guide through the labyrinth of phenomena; in the eye of philosophy it is a preconceived plan of action, purposeful of results. While science rests on law as a finality, philosophy seeks the power which ordains law; and, viewing law as the expression of will, it insists on the reality of will by all the evidence which science summons to establish the reality of law. Science claims law as an intelligible principle of coördination among phenomena; and philosophy claims an intelligible principle of coördination as the exclusive product of intelligence. The cosmos is comprehensible by thought, because it is the product of thought. Grant the mechanical nature of the processes of the world, the existence of a mechanism which does not express mind is something unthinkable.

Science is under no obligation to assume a strange garb and make affirmation of the predicates of philosophy. Such freedom may authorize science to ignore the predicates of philosophy, but it confers no privilege to deny them. As long as, maintaining its own character, it ignores the principles, postulates or axioms of philosophy, it cannot antagonize philosophy; but when it offers an argument *ex ignorantia* against the verdict of philosophy, all right thinking recognizes it as sophistical. It is impossible to grasp the meaning of law with the whole breadth of the intelligence, without apprehending it both as a rule and as an expression of ordaining will.

VI. As law, in its existence, proclaims necessarily a purposive ordination, so the correlation of events under law must necessarily be regarded as a result purposed in law. If law exists as the result of purpose, there must be a reason why it has been purposed; and the reason why can exist nowhere but in the results impressed by the law,—that is, in the results which take place according to the law. The coördination of results, therefore, is as much the expression of purpose as the law which embodies the principle of coördination. The fact that events take place according to law, instead of proving their disconnection with purpose, is the very circumstance which demonstrates their dependence on purpose. Caprice and confusion are not the marks of intelligence; high controlling intelligence always seeks its ends by fixed methods of action. The more clearly we discern the reign of universal law, the more clearly we discern the evidence of general design in the phenomena of the universe. The question whether events take place through law or through design is destitute of rational meaning; because, *first*, events are produced neither by law nor by design; and, *secondly*, if they are produced by design, it is, as we see, according to law; and if they are produced by law, it is according to design in the law. Law and design are so far from being mutually exclusive that, in truth, they are mutually inclusive. There is no law without design; and in nature the design of the law is worked out under the law.

VII. Passing from general design to special design, or the design supposed to be revealed in particular events, or particular correlations of material parts, the foremost question arising concerns the meaning of the metaphysical principle of design. Now, when parts are coadjusted, as in any mechanical combination, like a watch or a human hand, the instructive verdict of mankind is an affirmation of intention. This affirmation is prompted by the adjustment of *part to part*, and by the adjustment of the whole to its *result*. These two conceptions must be kept distinct. Let us for the moment leave out of consideration the question of design in the result, and note what is implied and what is not implied in the affirmation of design in the parts. We say instinctively that the coadjustment of parts implies design; but — 1. It does not imply that the action of the parts was designed to produce any result. 2. It does not imply that the result, if any, is useful, beautiful, or any otherwise characterized. 3. It does not imply that the result, if any, is either comprehended or comprehensible. 4. It does not imply that the adjustment is something wholly comprehensible. 5. It does not imply that the cause of the adjustment is either finite or not finite. 6. It does not imply that the conformations and collocations in the adjustment have been effected by any particular instruments, or according to any particular method. They may have been molded, hewed, carved, turned, or grown,— it is all the same.

These eliminations are of the utmost importance; but a careful appeal to consciousness demonstrates that our verdict is rendered without the least regard to any consideration save the fact of *coadjustment*,— mechanical coadjustment, in which the action of one part is continually reciprocated by the action of another part. Isolating the question of design from these customary entanglements, it is apparent that, when a case of mechanical coadjustment is presented, it is not pertinent to consider whether it is a product of man or of nature. It either implies design absolutely, or it does not imply design at all. The same combination cannot imply design when viewed as a human product, and have no significance or allowable interpretation when viewed as a natural product. The consideration that it has come into existence by a method of evolution, or by any other method, is as alien from the question as if the method had been by an envelope-making machine, or by carpentry, or smithery. It does not add to the conclusiveness of the statement to suggest that a method of evolution may and must have been established by design, and that consequently the ends which it attained may and must have been designed, both in general and in particular. The suggestion, however, is valid, and is perfectly in parallelism with the inference of design directly from adjustment. If the recognition of design, therefore, is legitimate, without any regard to the teleological significance of the products of adjustment, the most radical profession of nescience of the "designs of Nature" may admit that some design is revealed in the simple fact of structural adjustment, even if it were not designed to produce what it produces.

This is not that remote and hypothetical admission of design which recognizes simply the possibility that the whole system of nature may exist for some design; but it is an affirmative and necessary recognition of design as the logical antecedent of all coördinations interpretable in terms of intelligence.

VIII. Besides mutual adjustment of structural parts, we may consider the meaning of adjustments to a general concept. All that we know of fundamental plans of structure in the organic world is but a body of facts exemplifying adjustment of parts, not alone to each other, but to an archetypal conception,—an intelligential standard. It is frequently suggested that fundamental relationships have resulted from the law of heredity, with progressive divergence. That, probably, is a valid scientific account to give of what have been styled *plans* of organization; and every one is free to rest in the finality of science. But if our minds are so constituted that we irresistibly conclude design from coördination, regardless of the instrumentality or means by which the coördination becomes expressed in matter, then heredity with divergence is not an ultimate explanation, and every man is at liberty, without reproach, to pass beyond the pale of science, and recognize heredity as a thoughtful determination fixed for the purpose of introducing order and method into the organic world as we find them. So the mathematical order of the solar system is explicable in scientific terms by ascribing it to the cooling of a primitive nebula; but the forces engaged in the evolution of a planetary system must be rationally conceived as merely the instruments which work out symmetrical results coordinated to a general concept or plan. If, finally, the deepest law of nature is the law of evolution, we may recognize that as the all-embracing principle under which events emerge into being; but reason can never be divested of the simple conviction that events coördinated on so comprehensive a scale, and coördinated to so vast a scheme, give expression to purpose equally vast and comprehensive. The explanations of science are held to be valid, but they do not go far enough; they are not ultimate explanations. By the inherent principles of our mental being we postulate and posit motive and agency behind the last explanation of science.

IX. As design is the necessary implication of parts coordinated to each other, or to a general concept, so metaphysical cause is the only rational explanation of those ultimate physical antecedents which belong to the category of sub-causes or scientific causes. Of metaphysical cause science professes to have no knowledge, holding that invariable antecedence is the scientific conception of causation. But, manifestly, no phenomenon comes into existence *because* another phenomenon precedes. The precedence is the sign of antecedent efficiency. So the law under which a phenomenon arises is modal, not causal, and implies prior ordination, as the subordinated event implies transcendent causation. The *conditio sine qua non* of a phenomenon is not its essential cause, but the condition of the operativeness of a certain law which expresses a method of activity of essential cause. The notion of metaphysical cause is therefore the underlying ground of all the ultimate conception of science.

It is well understood that even metaphysical — that is, ultimate and essential — cause becomes efficient and actual only under the concurrence of certain conditions, which, because they contribute to the result, may be denominated concauses. We may define cause, if we please, as the whole body of coexistences without which a result would not exist. This is a complex but perfectly intelligible conception. It *may* be best to employ the true cause in such a sense. But then we have no name for that one of the coexistences which is the ultimate, self-sustained and direct efficiency in the effectuation. For instance, a seed placed in the ground germinates and grows into a cabbage. Of course the totality of causation concerned embraces all the causes, concauses and conditions which have to coact and coexist during the process of germination and growth. They consist, in part, of a duly organized and living seed, a location in the soil, the presence of moisture and light, and the activity of certain physiological forces in the seed and developing tissues of the plant. In a certain sense moisture is causal and light is causal, and vegetable aliment is causal. Their causality becomes active, however, only on the condition of an organized seed, and on the condition that it finds lodgment in the soil, and on the condition that the grub is kept away. While thus certain concurrences are concausal, others are conditioning. More immediately causal, but conditioned on all the concausation and conditions just mentioned, is the physical or physiological action which reveals itself in the absorption of solutions and gases from the soil and the atmosphere, the chemical compounding and preparation of them in protoplasm and the various juices, the conveyance of them to the various parts of the growing plant, and the exhalation of vapor and gases which are useless to the plant. It is certainly in these activities that we approach nearest to the seat of operation of efficient cause. But while these involve such causation as is expressed by capillarity, endosmose, chemism and exhalation, a moment's consideration shows that, after all, these are but *instrumental* agencies or sub-causes. These physiological movements and changes are not self-maintained; they are not ultimate causalities;

they are caused; they have to be explained and accounted for; they imply some real cause whose bidding they execute. Still more manifest is this when we note the plan and method and correlation of their activity. They build; they create mathematical forms and mechanical structures; they fit part to part; they think, they foresee, they purpose,—unless they are the mere servants of some intelligent cause. *That is the* CAUSE, therefore,—ultimate, self-sustained, voluntary and discerning, and working toward ultimate and thinkable ends,—which employs these instrumentalities under the concurring conditions and coactions, to select, move and dispose material with reference to the organized result,—guided while it acts physically on matter, by a clear conception of a structural end, and an intelligent selection and arrangement of material suited most perfectly for the realization of the end.

The notion of metaphysical cause, in spite of the formal restriction of the logic of science, has found constant expression in scientific language under the name of *force.* This, like the assumed atom and molecule of physics, the ethereal medium and the ultimate incompressibility of matter is a purely metaphysical conception. It is a name which the necessities of thinking have impelled us to adopt for the efficiency transmitted from or through the phenomenon which stands in the place of invariable antecedent. Yet the ordinary use of this term in the pages of science leaves questions still deeper which offer themselves as subjects of analytic thought. Is force an entity or an attribute? If an entity, is it self-acting or subordinated? If subordinated, what is the nature of the power which subordinates it? If self-acting, then the discernment and design revealed in the results of its activity are attributes which characterize a demiurge. But if we say force is an entity which produces results, what is the means by which it produces them? Are not all results produced by force, and is not our reasoning thus reduced to the proposition that the entity force employs force to produce results? This proposition is unintelligible, and shows that the conception of force as an entity is absurd. *Force is an attribute.*

But if force must be conceived as an attribute, what is the nature of its subject? *What* is it which exerts or manifests force? To say that the attribute force exerts itself is to make it both attribute and subject. Something which is not force, but which is capable of exerting force, is therefore necessarily implied in the conception of force. Is matter the subject? Then, *first*, it is a subject which thinks, and selects, and purposes; for the results of force are thoughtful, and selective, and purposive, and matter does thus possess a "power and potency" of psychic results. But, *secondly*, we are not certain that matter possesses a special subjective nature. We only know matter phenomenally, and it may easily be that phenomena constitute all there is of matter in itself. Yet phenomena are manifestations of something possessing the power to produce them. The phenomena which we cognize as matter are manifestations of force. If there be no subject-matter there must be some other subject revealing itself in the phenomena, which we group under the designation of matter. There must be somewhere a matter-subject. We are driven, then, to the recognition of an intelligent subject as the ground of the attribute of force, manifesting its activities in the being of what we call matter, as well as in the changes which are impressed upon matter.

The inquiry does not end even here; for it remains to ascertain what is the mode of origin of force from its subject. What is the method by which the subject reveals the attribute of force? Is forceful emanation from the subject an unconscious and continuous necessity of its being, or is it a conscious and voluntary activity? If necessary, then some higher power has imposed the necessity, and the supposed force is an effect, instead of a prime efficiency; if unconscious, then some higher intelligence directs according to the laws of conscious thought, and the supposed subject has not the attributes of the force-subject; for coördination of products implies at least two things consciously apprehended, both in their separateness and in their relation ; unconscious intelligence is a nugatory expression, for consciousness is the prime moment of intelligence; intelligential action in an unconscious agent implies the control of a conscious intelligence. If, on the contrary, forceful manifestations are effected through the method of volition, then the subject which constitutes the ground of all cosmical force is possessed of will as well as intellect and susceptibility to motive, and is consequently a personal entity,— an entity thinking, feeling and willing with reference to that which is objective to itself.

At this ultimate stadium of analytic thought, we are confronted by a truth which staggers and awes us by its import. Instead of finding ourselves authorized by science to remand the supernatural beyond the limits of the material world, we are constrained by philosophy to recognize *in* the material world only that efficiency which has been designated supernatural. *Natural* efficiency is only the dream of ignorance. All force is intelligential. The system of Nature is merely the theater of its activity in human times and before human eyes. If the words "supernatural" and "creative" possess any significance, they mean only an extraordinary, or hitherto unnoticed, mode of action of supreme efficiency, and not an intervention in a scheme of events sustained by some diverse and independent causation. The contemplations of science are suited, therefore, to awaken not alone the imagination, and sentiments of the beautiful and sublime, but feelings, also, of awe and reverence. The world, as the elder Agassiz so eloquently taught, is the theater of a divine activity, and an intelligent and perpetual revelation of the divine Being and attributes.

Thus all the distinctive doctrinal enunciations of modern science carry implications which reach beyond the peculiar domain of science. This, as I have shown, is true of the assumption that, in any case, observations have been actually made; that phenomena have been actually cognized; that there is any objective reality concerned in the cognition of phenomena; that principles of classification underlie phenomena; that the search for the unification of phenomena is not vain; that the progress of natural events may be safely traced into the future and the past; that like effects may be expected to proceed under similar conditions, from like causes; that natural law possesses validity, and secures order and persistence in the flow of events. These universally accepted doctrines of science can be admitted only on the admission that all the testimony of consciousness is valid; that the truths intuitively apprehended in reason are absolute and eternal; that the government of the world rests on a rational basis, and that events are to be interpreted in terms of intelligence; that law and order are the expressions of intelligence;

that uniformity of succession is only the phenomenal symbol of underlying efficiency; that in the midst of all the concausation accompanying an effect there is one coexistence which must be viewed as efficient, metaphysical cause; that all force rests back ultimately in a subject which possesses the attributes of intelligent personality. The principle of continuity is a metaphysical principle, but it underlies the deepest and broadest of the fundamental doctrines of modern science. The phenomena correlated in so-called evolutionary series rest on and express this principle. It guides us in tracing the forms of inorganic matter from a primitive homogeneous state, and also the forms of organic matter from a primitive vitalized plasma. The evolutionary arrangement of phenomena may, indeed, be ascertained empirically, but the principle of continuity points to the rule of arrangement and the bond of union. So science may empirically search out and ascertain the place and mode and material causation of origins, but essential causes lie quite within the region of the metaphenomenal.

It appears, therefore, as Lewes states, that "the fundamental ideas of modern science are as transcendental as any of the axioms of ancient philosophy," and that "every physical problem involves metempirical elements." Besides the metaphysical implications of the current doctrines of science, all its fundamental conceptions — self, substance, cause, force, life, order, law, purpose, relation, unity, identity, continuity, evolution, natural selection, species, genus, order, class — are purely metaphysical concepts or ideas. These are not the objects of sensible perception, like the phenomenal data of science, but are apprehended by the rational insight. They have no legitimate place in that narrow sphere which science sometimes mistakenly allots to itself. Many of them are the logical antecedents and necessary conditions of the possibility of experience. They precede and legitimate all our cognitions and judgments concerning the sensible world, and act as the constitutive and coördinating principles among our perceptions. They render possible the logical contemplation and intelligent penetration of nature. They constitute the bond of consistence and coherence in the fabric of science, and illume the system of the cosmos with the supernal light of thought.

The foregoing suggestions are intended to reveal clearly to the intelligent reader the existence of a realm of legitimate thought deeper than the data of physical science; presupposed, indeed, by all the logic of science, and sole sponsor for all the validity which the principles of science can ever acquire. The effect is not to impair the authority of science, but to rationalize it, and purge it of empiricism and dogmatism. The moral is that science, from its platform, is not competent to utter conclusions on themes which lie over in the realm of metaphysics; but when it gives utterances, either affirmative or negative, on questions essentially metaphenomenal, it must proceed from the axioms of metaphysics, and not from the inductions based on sensible phenomena.

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